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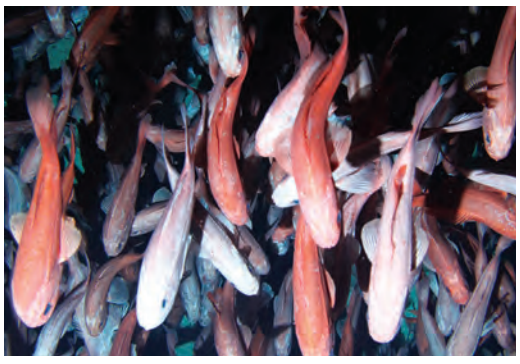
2019/0800 May 2022

# Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery: 2020 and 2021

PART 1

2021



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***Cover photographs***

*Front cover, jackass morwong, orange roughy, blue grenadier, and flathead.*

***Report structure***

*Part 1 of this report describes the Tier 1 assessments of 2021. Part 2 describes the Tier 4 and Tier 5 assessments, catch rate standardisations and other work contributing to the assessment and management of SESSF stocks in 2021.*

# Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery 2020 and 2021

Part 1: 2021

G.N. Tuck
May 2022
Report 2019/0800

Australian Fisheries Management Authority

# Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery: 2021

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# 1. Non-Technical Summary

*Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery 2020 and 2021*

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**OBJECTIVES:**

- Provide quantitative and qualitative species assessments in support of the four SESSFRAG assessment groups, including RBC calculations within the SESSF harvest strategy framework
- 2020: Provide Tier 1 assessments for Gummy Shark, Eastern Redfish and School Whiting; Tier 4 assessments for John Dory, Mirror Dory, Ocean Perch, OreoBasket, Ribaldo, Royal Red Prawn, Sawshark and Silver Trevally; and Tier 5 for Blue-eye Trevalla
- 2021: Provide Tier 1 assessments for Eastern Orange Roughy, Blue Grenadier, Eastern Jackass Morwong and Silver Warehou; Tier 4 for Mirror Dory and Tier 5 for E/W Deepwater Shark

### *Outcomes Achieved - 2021*

The 2021 assessments of stock status of the key Southern and Eastern Scalefish and Shark fishery (SESSF) species are based on the methods presented in this report. Documented are the latest quantitative assessments for the SESSF quota species. Typical assessment results provide indications of current stock status, in addition to an application of the recently introduced Commonwealth fishery harvest control rules that determine a Recommended Biological Catch (RBC). These assessment outputs are a critical component of the management and Total Allowable Catch (TAC) setting process for these fisheries. The results from these studies are being used by SESSFRAG, industry and management to help manage the fishery in accordance with agreed sustainability objectives.

## 1.1 South East RAG Species

*Blue Grenadier*

This chapter updates the agreed base case for a Tier 1 assessment of Blue Grenadier (*Macruronus novaezelandiae*). The last full assessment was conducted in 2018. The 2018 assessment was updated by the inclusion of data up to the end of 2020, which entails an additional three years of catch, discard, CPUE, length and age data and ageing error updates. The agreed base case now includes estimation of both female and male natural mortality, and no longer includes the FIS survey results.

Results of the base case show reasonably good fits to the length-composition data, conditional age at length, egg and acoustic surveys and discard mass. As has been noted in previous Blue Grenadier assessments, the fit to the standardized non-spawning catch-rate index is generally poor; the model is unable to fit to the high early catch rates and over-estimates catch rates during the early 2000s. More recent catch rates fit reasonably well, including the recent marked increase in catch rate in 2019 and 2020.

The estimated time series of recruitment under the base-case parameter set shows the typical episodic nature of Blue Grenadier recruitment, with strong year-classes in 1979, the mid-1980s, 1994, and 2003, with very little recruitment between these years. However, recent recruitments are more stable, as was first observed in the 2018 assessment. The trajectories of spawning biomass show increases and decreases in spawning biomass as strong cohorts move into and out of the spawning population. For the base case model, the estimated virgin female spawning biomass ($SSB_0$) is 37,445 tonnes and the projected 2022 spawning stock biomass will be 155% of $SSB_0$ (projected assuming 2020 catches in 2021). The 2022 recommended biological catch (RBC) under the 20:35:48 harvest control rule is 23,777 t, with 245 t estimated discards (23,532 t retained). The long-term RBC is 7,100 t, with 183 t discards.

*Eastern Jackass Morwong*

This chapter updates the 2018 Tier 1 assessment of eastern Jackass Morwong (*Nemadactylus macropterus*) to provide estimates of stock status in the SESSF at the start of 2022. The 2018 stock assessment has been updated with the inclusion of data up to the end of 2020, comprising an additional three years of catch, discard, CPUE, length and age data and ageing error updates, including revisions to historical catch series, length frequencies and discard rates. A range of sensitivities were explored.

The base-case assessment estimates that the projected 2022 spawning stock biomass will be 15% of unexploited spawning stock biomass ($SSB_0$), with recruitment from 2016 onwards projected using a low recruitment scenario, using the average of the ten most recently estimated recruitment deviations, from 2006-2015. Under the agreed 20:35:48 harvest control rule, the 2022 recommended biological catch (RBC) is 0 t, with the long-term yield (assuming low recruitment in the future) of 91 t. The average RBC over the three-year period 2022-2024 is 0 t and over the five-year period 2022-2026, the average RBC is 1 t. If recruitment from 2016 onwards is assumed to be average, the projected 2022 spawning stock biomass would be 22% of $SSB_0$.

The updated assessment produces markedly different results from the 2018 assessment, under both the average and the low recruitment scenarios. This is due to downward revisions to the 13 of most recent 15 years of recruitment estimates from the 2018 assessment (for the period 1998-2012), poor recruitment estimates for the three new years of recruitment estimated in the 2021 assessment (for the years 2013-2015), a continuing decline in recent catches, a continuing decline in the recent CPUE

indices and an improved fit to the most recent CPUE data points, partly due to the implementation of a low recruitment scenario.

*Eastern Orange Roughy*

This chapter updates the 2017 eastern zone Orange Roughy (*Hoplostethus atlanticus*) stock assessment to include revised modelling assumptions and new data for 2020. The objective of the 2021 assessment is to account for the uncertainty in *M* by estimating it within the assessment using an informative prior developed from New Zealand Orange Roughy assessments.

The 2021 base-case assessment updates the 2017 assessment with recent catch, relative estimates of female spawning biomass from the 2019 acoustic towed surveys at St Helens Hill and St Patricks Head, and new age composition data from the 2019 acoustic survey. Two major changes were made to the previous assessment: natural mortality is now estimated within the assessment and the plus-group are increased from 80 to 120 years.

The median estimate of unfished female spawning biomass from the MCMC analysis was 38,924 t, slightly lower than the MPD estimate of 40,479 t. The current 2022 female spawning biomass is estimated to be 11,644 t from the MCMC and 13,126 t from the MPD. Relative spawning biomass in 2022 is estimated at 30% of unfished levels from the MCMC and 32.4% of unfished levels from the MPD. Natural mortality was successfully estimated within the assessment. The median estimate of natural mortality from the MCMC analysis is $M$=0.0393 $yr^{-1}$, which is slightly higher than the MPD estimate of $M$=0.0386 $yr^{-1}$. The recommended biological catch (RBC) for 2022 from the MCMC analysis is 681 t, lower than the MPD estimate for 2022 of 944 t. The average RBC over the next three years (2022-2024) is 737 t from the MCMC analysis and 1,025 t from the MPD. There is a high level of uncertainty in the estimated RBC, with the 75% and 95% credible intervals from the MCMC analysis for the 2022 RBC being 287–1,316 t and 119–1,645 t respectively.

Further MCMC analysis was undertaken to evaluate scenarios of fixed catch projections of 550, 650, 737, 850 and 950 t $yr^{-1}$ and a catch scenario proposed by industry of 1,166 t in 2022, 1,055 t in 2023 and 950 t $yr^{-1}$ thereafter. The projections show that female spawning biomass is estimated to increase under all the fixed catch scenarios considered with the probability of the stock being below the limit reference point of 20% unfished spawning biomass in both 2024 and 2031 being less than 0.5%. Under the lowest constant catch scenario of 550 t $yr^{-1}$, stock status is estimated to be 0.317 and 0.348 in 2024 and 2031 respectively. Under the highest constant catch scenario of 950 t $yr^{-1}$, stock status is estimated to be 0.312 and 0.323 in 2024 and 2031 respectively. Under the industry proposed scenario stock status estimated to be 0.309 and 0.321 in 2024 and 2031 respectively. When the SESSF harvest control rule is used to set RBCs, the stock status is estimated to be 0.316 and 0.330 in 2024 and 2031 respectively.

*School Whiting*

This chapter presents School Whiting (*Sillago flindersi*) RBC projections from the 2020 stock assessment using a modified target MEY reference proxy of 40% instead of 48%. The 2020 School Whiting stock assessment estimates that current spawning stock biomass (at the beginning of 2021) is 41% of unexploited spawning stock biomass ($SSB_0$). Under the agreed 20:35:48 harvest control rule, the 2021 recommended biological catch (RBC) is 2,140 t. The RBC averaged over the three-year period of 2021-2023 is 2,237 t.

If the default (proxy) target reference point (48%) used in the SESSF harvest control rule, and specifically as used by AFMA for School Whiting, is reduced to 40%, a modified 20:35:40 harvest

control rule can be applied. This lower target allows the stock to be fished to a lower target biomass (40% of unfished spawning stock biomass ($SSB_0$)). Under a revised 40% target, the 2021 recommended biological catch (RBC) would be 2,753 t. The RBC, calculated under a 20:35:40 harvest control rule, averaged over the three-year period of 2021-2023 is 2,730 t.

*Silver Warehou*

This chapter presents a quantitative Tier 1 assessment of Silver Warehou (*Seriolella punctata*) to provide stock status estimates at the start of 2022 and describes the base case. The 2018 base case has been updated with the inclusion of data up to the end of 2020, which entails an additional three years of catch, discard, CPUE, length and age data, along with ageing error updates, revisions to historical catch series, length frequencies and discard rates.

The assessment estimates that the projected 2022 stock status will be 29% of unfished spawning stock biomass ($SSB_0$) , projected assuming 2020 catches in 2021, with recruitment from 2016 onwards assumed to be below average, fixed at the average of 2011-2015 levels. The assessment suggests that stock status was as low as 21% of $SSB_0$ in 2016. Under the 20:35:48 harvest control rule, the 2022 recommended biological catch (RBC) is 587 t, while the long-term yield (assuming continuation of low recruitment) is 591 t. The average RBC over the three-year period 2022-2024 is 581 t.

This assessment has seen a continuation of below average recruitment noted in the last three assessments with the last 12 years of estimated recruitment all below average. This continuation of below average recruitment resulted in the base case for this assessment moving to low recruitments projected forward from 2016. This change reduced the severity of retrospective patterns observed in previous assessments.

*Tiger Flathead*

This chapter presents results of fixed catch projections for Tiger Flathead (*Neoplatycephalus richardsoni*) to provide information on possible projected stock status in light of changes to both catches and CPUE following the 2019 Tiger Flathead stock assessment.

Updated data used from the 2019 assessment, including preliminary catch (combined Commonwealth and state catch) for 2019-2020, estimated 2021 catch and updated CPUE series to the end of 2020 were included in this analysis. Updates to age and length composition data were not available and were not included. These updates to catch and CPUE alone resulted in a revision downwards to the 2020 stock status, from 34% in the last stock assessment to 32% in this analysis. These changes are due to revisions to the catches (2017-2021) and to the revised CPUE series, which has a downturn at the end of the time series (2019-2020) for the Danish seine CPUE. The eastern trawl and Tasmanian trawl CPUE series do not show the same downturn at the end of the CPUE series as Danish seine, with both trawl CPUE relatively flat in the period 2019-2020. Projecting forward to 2022 takes the stock status to 35% at the start of 2022, and this is expected to recover to 37% at the start of 2025, assuming that the RBC is caught in 2023 and 2024 and there is average recruitment from 2017 onwards. Changes to the projected stock status when the 2019 base case is updated are a consistent 1% reduction in stock status in the period 2020-2025, assuming the RBC is caught each year.

KEYWORDS: fishery management, southern and eastern scalefish and shark fishery, stock assessment, trawl fishery, non-trawl fishery

# 2. Background

The Southern and Eastern Scalefish and Shark Fishery (SESSF) is a Commonwealth-managed, multi-species and multi-gear fishery that catches over 80 species of commercial value and is the main provider of fresh fish to the Sydney and Melbourne markets. Precursors of this fishery have been operating for more than 85 years. Catches are taken from both inshore and offshore waters, as well as offshore seamounts, and the fishery extends from Fraser Island in Queensland to south west Western Australia.

Management of the SESSF is based on a mixture of input and output controls, with over 20 commercial species or species groups currently under quota management. For the previous South East Fishery (SEF), there were 17 species or species groups managed using TACs. Five of these species had their own species assessment groups (SAGs) – Orange Roughy (ORAG), Eastern Gemfish (EGAG), Blue Grenadier (BGAG), Blue Warehou (BWAG), and Redfish (RAG). The assessment groups comprise scientists, fishers, managers and (sometimes) conservation members, meeting several times in a year, and producing an annual stock assessment report based on quantitative species assessments. The previous Southern Shark Fishery (SSF), with its own assessment group (SharkRAG), harvested two main species (Gummy and School Shark), but with significant catches of Saw Shark and Elephantfish.

In 2003, these assessment groups were restructured and their terms of reference redefined. Part of the rationale for the amalgamation of the previous separately managed fisheries was to move towards a more ecosystem-based system of fishery management (EBFM) for this suite of fisheries, which overlap in area and exploit a common set of species. The restructure of the assessment groups was undertaken to better reflect the ecological system on which the fishery rests. To that end, the assessment group structure now comprises:

- SESSFRAG (an umbrella assessment group for the whole SESSF)
- South East Resource Assessment Group (slope, shelf and deep water species)
- Shark Resource Assessment Group (shark species)
- Great Australian Bight Resource Assessment Group (GAB species)

Each of the depth-related assessment groups is responsible for undertaking stock assessments for a suite of key species, and for reporting on the status of those species to SESSFRAG. The plan for the Resource Assessment Groups (South East, GAB and Shark RAGs) is to focus on suites of species, rather than on each species in isolation. This approach has helped to identify common factors affecting these species (such as environmental conditions), as well as consideration of marketing and management factors on key indicators such as catch rates.

The quantitative assessments produced annually by the Resource Assessment Groups are a key component of the TAC setting process for the SESSF. For assessment purposes, stocks of the SESSF currently fall under a Tier system whereby those with better quality data and more robust assessments fall under Tier 1, while those with less reliable available information are in Tiers 4 and 5. To support the assessment work of the four Resource Assessment Groups, the aims of the work conducted in this report were to develop new assessments if necessary (under all Tier levels), and update and improve existing ones for priority species in the SESSF.

## 3. Need

A stock assessment that includes the most up-to-date information and considers a range of hypotheses about the resource dynamics and the associated fisheries is a key need for the management of a resource. In particular, the information contained in a stock assessment is critical for selecting harvest strategies and setting Total Allowable Catches.

## 4. Objectives

These Objectives include a description of the SESSFRAG agreed changes to the assessment schedule and may differ from the objectives in the original contract:

- Provide quantitative and qualitative species assessments in support of the four SESSFRAG assessment groups, including RBC calculations within the SESSF harvest strategy framework

- 2020: Provide Tier 1 assessments for Gummy Shark, Eastern Redfish and School Whiting; Tier 4 assessments for John Dory, Mirror Dory, Ocean Perch, OreoBasket, Ribaldo, Royal Red Prawn, Sawshark and Silver Trevally; and Tier 5 for Blue-eye Trevalla

- 2021: Provide Tier 1 assessments for Eastern Orange Roughy, Blue Grenadier, Eastern Jackass Morwong and Silver Warehou; Tier 4 for Mirror Dory and Tier 5 for E/W Deepwater Shark

# 14. Tiger Flathead (*Neoplatycephalus richardsoni*) projections based on CPUE updates to 2020, estimated catch to 2021 and projected catch scenarios to 2025

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## *14.1 Executive Summary*

This document presents results of fixed catch projections for Tiger Flathead (*Neoplatycephalus richardsoni*) to provide information on possible projected stock status in light of changes to both catches and CPUE following the 2019 Tiger Flathead stock assessment.

Updated data used from the 2019 assessment, including preliminary catch (combined Commonwealth and state catch) for 2019-2020, estimated 2021 catch and updated CPUE series to the end of 2020 were included in this analysis. Updates to age and length composition data were not available and were not included. These updates to catch and CPUE alone resulted in a revision downwards to the 2020 stock status, from 34% in the last stock assessment to 32% in this analysis. These changes are due to revisions to the catches (2017-2021) and to the revised CPUE series, which has a downturn at the end of the time series (2019-2020) for the Danish seine CPUE. The eastern trawl and Tasmanian trawl CPUE series do not show the same downturn at the end of the CPUE series as Danish seine, with both trawl CPUE relatively flat in the period 2019-2020. Projecting forward to 2022 takes the stock status to 35% at the start of 2022, and this is expected to recover to 37% at the start of 2025, assuming that the RBC is caught in 2023 and 2024 and there is average recruitment from 2017 onwards.

Changes to the projected stock status when the 2019 base case is updated are a consistent 1% reduction in stock status in the period 2020-2025, assuming the RBC is caught each year. If projections are made under a constant catch of 2,400 t, there is a lightly faster recovery of the stock status towards $B_{40}$, the target reference point for Tiger Flathead.

## *14.2 Previous assessment and changes to data*

### 14.2.1 *The fishery*

Tiger flathead have been caught commercially in the south eastern region of Australia since the development of the trawl fishery in 1915. They are endemic to Australian waters and are caught mainly on the continental shelf and upper slope waters from northern NSW to Tasmania and through Bass Strait. Historical records (e.g. Fairbridge, 1948; Allen, 1989; Klaer, 2005) show that steam trawlers caught tiger flathead from 1915 to about 1960. A Danish seine trawl fishery developed in the 1930s (Allen, 1989) and continues to the present day. Modern diesel trawling commenced in the 1970s.

### 14.2.2 *Biological parameters*

As male and female tiger flathead have different growth patterns (females are substantially larger), a two-sex model has been used.

The parameters of the von Bertalanffy growth equation are estimated by sex within the model-fitting procedure from age-at-length data. This approach accounts for the impact of gear selectivity on the age-at-length data collected from the fishery and the impact of ageing error. Three growth parameters are estimated for females (CV, $K$ and $l_{min}$), with only one growth parameter fixed ($l_{max}$ = 55.9), with this valued based on the estimate of $l_\infty$ obtained by Punt (2005) by fitting von Bertalanffy growth curves to data from SESSF Zones 10 and 20 (NSW and eastern Bass Strait). An offset to $K$ is estimated separately for males, with the other growth parameters using the same values as for female growth.

Estimates of the rate of natural mortality, $M$, reported in the literature vary from 0.21 to 0.46 $yr^{-1}$. This assessment uses a value of 0.27 $yr^{-1}$ as the base case estimate of $M$ as used in the previous assessment (Day, 2019) and as previously agreed to by SERAG. Sensitivity to this value is tested. The steepness of the stock-recruitment relationship, $h$, is estimated by the model, and for the base case is estimated to be 0.72.

Female tiger flathead become sexually mature at about three years of age, which corresponds to a length of about 30 cm (Klaer, 2010). Maturity is modelled as a logistic function, with 50% maturity fixed at 30 cm. Fecundity-at-length is assumed to be proportional to weight-at-length.

The parameters of the length-weight relationship are the same as those used in the previous assessment $a$=5.88 x $10^{-6}$, $b$=3.31 (Day, 2019), with these parameters originally obtained by fitting von Bertalanffy growth curves to data from SESSF Zones 10 and 20, NSW and eastern Bass Strait (Punt, 2005).

### 14.2.3 *Fleets*

The assessment data for Tiger Flathead have been separated into five 'fleets', which represent one or more gear, regional, or temporal differences in the fishery. Landings data from eastern Tasmania were separated from the catches from the other regions in the east, because the length compositions of catches from this area indicate that it lands larger fish.

1. Steam trawl – steam trawlers (1915 – 1961)
2. Danish seine – Danish seine from NSW, eastern Victoria and Bass Strait (1929 – 2020)
3. Eastern trawl – diesel otter trawlers from NSW, eastern Victoria and Bass Strait (1971 – 2020)
4. Tasmanian trawl – diesel otter trawlers from eastern Tasmania (1985 – 2020)
5. Fishery Independent Survey – (2008 – 2016)

### 14.2.4 *Species composition for the "tiger flathead" assessment*

The Commonwealth quota basket for "tiger flathead" actually comprises six separate CAAB codes (Thomson and Day 2019a). Two CAAB codes have commonly been used for the majority of the catch, usually well over 99%: tiger flathead (37296001) and generic (undifferentiated) flathead (37296000). While the use of these two codes has changed since the introduction of e-logs, both codes are thought to largely contain tiger flathead (*Platycephalus richardsoni*). The remaining four CAAB codes consist of toothy flathead, southern sand flathead, bluespotted flathead and southern bluespotted flathead. Of these, southern sand flathead catches ranged between 10 t and 20 t from 1985-1989 and less than 10 t since 1990. Catches of southern bluespotted flathead were 5 t in 1995, 1 t in 2017 and less than 1 t in all other years. Catches of southern sand flathead and bluespotted flathead were less than 1 t in all years. The Commonwealth catch of these four species which are not tiger flathead usually comprises

well less than 1% of the total Commonwealth catch. As such, the Commonwealth component of this catch is considered to be essentially tiger flathead catches.

State catches used in this assessment generally occur in shallower waters than Commonwealth and hence are more likely to contain sand flathead and bluespotted flathead. State catches from NSW, Victoria and Tasmania report tiger flathead separately from other flathead species and only tiger flathead catches are requested by CSIRO.

Small quantities (less than 2% of the total CDR in all years from 1985-2018, and usually less than 1%) of tiger flathead are reported in logbook catches from zones 40 (western Tasmania) and 50 (western Bass Strait). It seems that some of these records could be deepwater flathead (Thomson and Day 2019b), potentially misreported in the logbooks as tiger flathead. These western logbook catches are included in the total catch (the CDR), but are allocated to fleets as if these catches were taken in the east. The relative proportion of the catch by fleet (Danish seine, eastern trawl, Tasmanian trawl) for each year can only be obtained from the logbook records. However, the total Commonwealth catch comes from the CDR totals, as this is considered to be more accurate than the logbook totals. Hence the annual proportions of catch by (eastern) fleet are applied to the annual CDR (which includes western catches), but actually assumes all of the catch comes from the eastern fleets. Given the western catch is relatively small, this is unlikely to have a large impact, and follows the precedent used to distribute this (western) catch used in tiger flathead assessments in recent years.

### 14.2.5 *Previous assessment*

The most recent full quantitative stock assessment for Tiger Flathead using data up to 2018 was performed in 2019 (Day, 2019) using Stock Synthesis version SS-V3.30.14.05, (Methot et al., 2018).

### 14.2.6 *Landed catches*

A landed catch history for tiger flathead, separated into the four ‘fleets’, is available for all years from 1915 to 2018 (Table 14.1, Figure 14.1 and Figure 14.2). Landings from the FIS fleet were assumed to be zero, with the actual FIS catch included in the scaling up of logbook catches to landed catches.

Klaer (2005) describes the sources of information used to construct the historical landed catch record for each of the fleets to 1986. Quotas were introduced into the fishery in 1992, and from then onwards, records of landed catches as well as estimated catches from the logbook are available. The landings data give a more accurate measure of the landed catch than do the logbook data, but the logbook data contain more detail. For example, it is usually possible to separate logbook records, but not landing records, by fleet. The logbook catches for each fleet from 1992 onwards have been scaled up by the ratio of landed catches to logbook catches in each year (Thomson, 2002). Prior to 1992, the unscaled logbook catches are used.

In 2007 the quota year was changed from calendar year to the year extending from 1 May to 30 April, however the assessment is based on calendar years. All catches for recent years continue to be those made by calendar year, which may conflict with the fishing year TACs.

Small quantities of tiger flathead are caught in state waters. NSW state catches have been added to the eastern trawl fleet, Victorian state catches added to the Danish seine fleet and Tasmanian state catches have been added to the Tasmanian fleet.

In order to calculate the Recommended Biological Catch (RBC) for 2022, it is necessary to estimate the Commonwealth calendar year catch for 2021. The TAC (Table 14.2) was reduced in 2020 and increased closer to the 2019 TAC in 2021. For simplicity, catches by fleet in 2021 were assumed to be the same as catches by fleet in 2020.

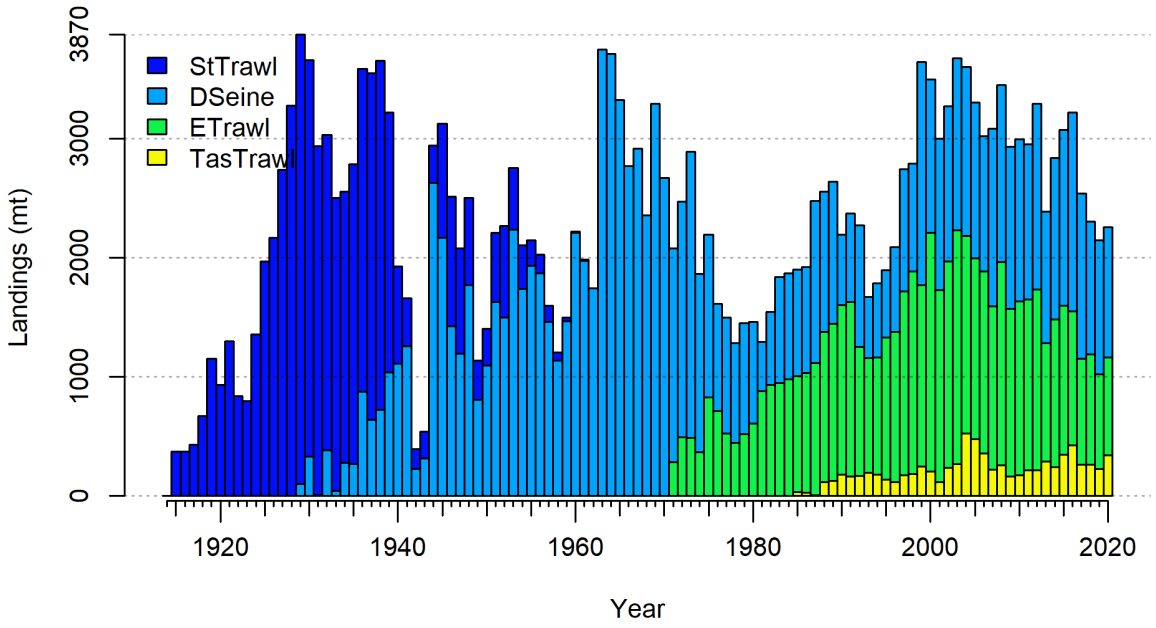


Figure 14.1. Total landed catch of tiger flathead by fleet (stacked) from 1915-2020.

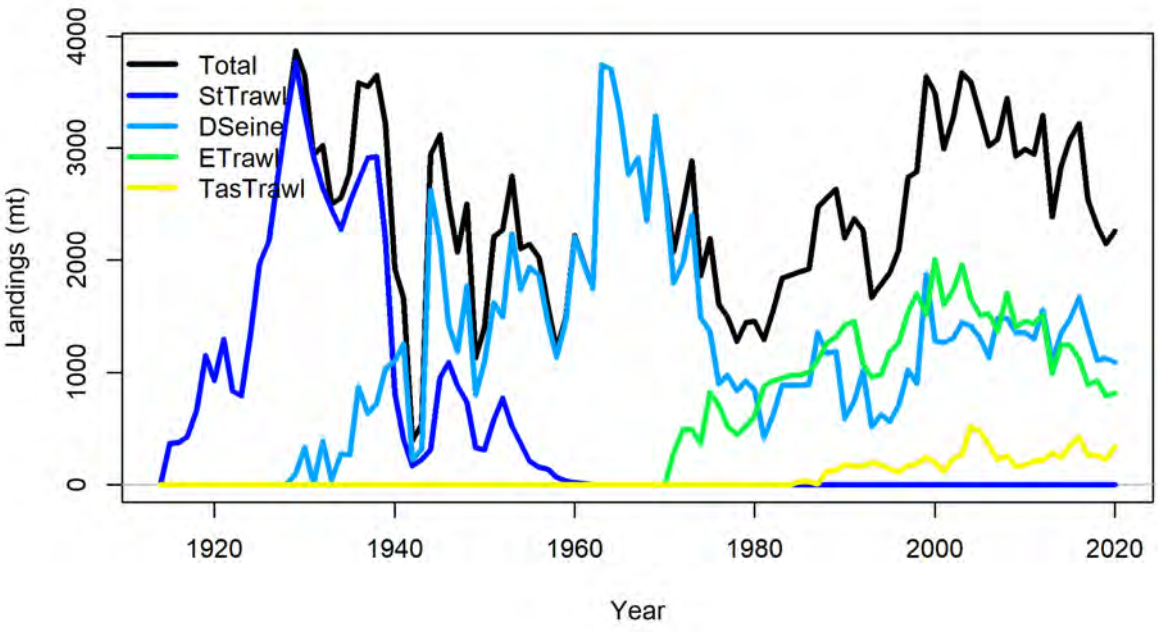


Figure 14.2. Total landed catch of tiger flathead by fleet from 1915-2020.

Table 14.1. Total retained catches (tonnes) of tiger flathead per fleet for calendar years from 1915-2021, used in the 2021 assessment update. Catches listed in bold (2017-2021) indicate updated catches, compared to the catches used in the 2019 assessment

| Year | Fleet<br>St<br>Trawl | D<br>Seine | E<br>Trawl | Tas<br>Trawl | Year | Fleet<br>St<br>Trawl | D<br>Seine | E<br>Trawl | Tas<br>Trawl | Year | Fleet<br>St<br>Trawl | D<br>Seine | E<br>Trawl | Tas<br>Trawl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1915 | 371 | 0 | 0 | 0 | 1951 | 583 | 1,625 | 0 | 0 | 1987 | 0 | 1,358 | 1,109 | 6 |
| 1916 | 373 | 0 | 0 | 0 | 1952 | 769 | 1,499 | 0 | 0 | 1988 | 0 | 1,177 | 1,263 | 116 |
| 1917 | 432 | 0 | 0 | 0 | 1953 | 517 | 2,235 | 0 | 0 | 1989 | 0 | 1,189 | 1,318 | 128 |
| 1918 | 671 | 0 | 0 | 0 | 1954 | 366 | 1,737 | 0 | 0 | 1990 | 0 | 591 | 1,425 | 178 |
| 1919 | 1,151 | 0 | 0 | 0 | 1955 | 211 | 1,932 | 0 | 0 | 1991 | 0 | 746 | 1,461 | 166 |
| 1920 | 931 | 0 | 0 | 0 | 1956 | 157 | 1,868 | 0 | 0 | 1992 | 0 | 1,019 | 1,080 | 170 |
| 1921 | 1,297 | 0 | 0 | 0 | 1957 | 139 | 1,459 | 0 | 0 | 1993 | 0 | 516 | 962 | 194 |
| 1922 | 840 | 0 | 0 | 0 | 1958 | 68 | 1,138 | 0 | 0 | 1994 | 0 | 626 | 982 | 178 |
| 1923 | 796 | 0 | 0 | 0 | 1959 | 32 | 1,467 | 0 | 0 | 1995 | 0 | 564 | 1,189 | 139 |
| 1924 | 1,356 | 0 | 0 | 0 | 1960 | 15 | 2,206 | 0 | 0 | 1996 | 0 | 711 | 1,265 | 114 |
| 1925 | 1,969 | 0 | 0 | 0 | 1961 | 9 | 1,974 | 0 | 0 | 1997 | 0 | 1,023 | 1,542 | 175 |
| 1926 | 2,167 | 0 | 0 | 0 | 1962 | 0 | 1,742 | 0 | 0 | 1998 | 0 | 905 | 1,700 | 186 |
| 1927 | 2,735 | 0 | 0 | 0 | 1963 | 0 | 3,745 | 0 | 0 | 1999 | 0 | 1,873 | 1,520 | 248 |
| 1928 | 3,277 | 0 | 0 | 0 | 1964 | 0 | 3,707 | 0 | 0 | 2000 | 0 | 1,286 | 2,006 | 349 |
| 1929 | 3,768 | 102 | 0 | 0 | 1965 | 0 | 3,322 | 0 | 0 | 2001 | 0 | 1,269 | 1,612 | 115 |
| 1930 | 3,329 | 330 | 0 | 0 | 1966 | 0 | 2,769 | 0 | 0 | 2002 | 0 | 1,305 | 1,731 | 236 |
| 1931 | 2,932 | 4 | 0 | 0 | 1967 | 0 | 2,912 | 0 | 0 | 2003 | 0 | 1,446 | 1,957 | 270 |
| 1932 | 2,642 | 385 | 0 | 0 | 1968 | 0 | 2,355 | 0 | 0 | 2004 | 0 | 1,418 | 1,658 | 522 |
| 1933 | 2,456 | 44 | 0 | 0 | 1969 | 0 | 3,289 | 0 | 0 | 2005 | 0 | 1,307 | 1,516 | 476 |
| 1934 | 2,278 | 276 | 0 | 0 | 1970 | 0 | 2,667 | 0 | 0 | 2006 | 0 | 1,132 | 1,526 | 359 |
| 1935 | 2,514 | 270 | 0 | 0 | 1971 | 0 | 1,793 | 286 | 0 | 2007 | 0 | 1,488 | 1,368 | 223 |
| 1936 | 2,712 | 872 | 0 | 0 | 1972 | 0 | 1,981 | 491 | 0 | 2008 | 0 | 1,487 | 1,705 | 255 |
| 1937 | 2,912 | 637 | 0 | 0 | 1973 | 0 | 2,397 | 490 | 0 | 2009 | 0 | 1,358 | 1,408 | 163 |
| 1938 | 2,924 | 725 | 0 | 0 | 1974 | 0 | 1,493 | 369 | 0 | 2010 | 0 | 1,359 | 1,458 | 175 |
| 1939 | 2,185 | 1,035 | 0 | 0 | 1975 | 0 | 1,367 | 827 | 0 | 2011 | 0 | 1,300 | 1,435 | 214 |
| 1940 | 815 | 1,108 | 0 | 0 | 1976 | 0 | 900 | 712 | 0 | 2012 | 0 | 1,560 | 1,516 | 217 |
| 1941 | 403 | 1,255 | 0 | 0 | 1977 | 0 | 977 | 522 | 0 | 2013 | 0 | 1,103 | 995 | 287 |
| 1942 | 167 | 225 | 0 | 0 | 1978 | 0 | 836 | 446 | 0 | 2014 | 0 | 1,352 | 1,244 | 239 |
| 1943 | 223 | 317 | 0 | 0 | 1979 | 0 | 928 | 520 | 0 | 2015 | 0 | 1,476 | 1,248 | 348 |
| 1944 | 315 | 2,624 | 0 | 0 | 1980 | 0 | 851 | 609 | 0 | 2016 | 0 | 1,671 | 1,126 | 422 |
| 1945 | 953 | 2,168 | 0 | 0 | 1981 | 0 | 418 | 877 | 0 | 2017 | 0 | **1,386** | **893** | **260** |
| 1946 | 1,088 | 1,425 | 0 | 0 | 1982 | 0 | 615 | 930 | 0 | 2018 | 0 | **1,110** | **926** | **264** |
| 1947 | 884 | 1,193 | 0 | 0 | 1983 | 0 | 889 | 950 | 0 | 2019 | 0 | **1,127** | **796** | **224** |
| 1948 | 735 | 1,767 | 0 | 0 | 1984 | 0 | 890 | 978 | 0 | 2020 | 0 | **1,096** | **819** | **342** |
| 1949 | 330 | 804 | 0 | 0 | 1985 | 0 | 890 | 978 | 30 | 2021* | 0 | **1,096** | **819** | **362** |
| 1950 | 310 | 1,095 | 0 | 0 | 1986 | 0 | 892 | 1,005 | 26 | | | | | |

*2021 catches are estimated

Table 14.2. Total allowable catch (t) from 1992 to 2021/22.

| Year | TAC Agreed |
|---|---|
| 1992 | 3000 |
| 1993 | 3000 |
| 1994 | 3500 |
| 1995 | 3500 |
| 1996 | 3500 |
| 1997 | 3500 |
| 1998 | 3500 |
| 1999 | 3500 |
| 2000 | 3500 |
| 2001 | 3500 |
| 2002 | 3500 |
| 2003 | 3500 |
| 2004 | 3500 |
| 2005 | 3150 |
| 2006 | 3000 |
| 2007 | 3015 |
| 2008/09 | 2850 |
| 2009/10 | 2850 |
| 2010/11 | 2750 |
| 2011/12 | 2750 |
| 2012/13 | 2750 |
| 2013/14 | 2750 |
| 2014/15 | 2878 |
| 2015/16 | 2860 |
| 2016/17 | 2882 |
| 2017/18 | 2712 |
| 2018/19 | 2507 |
| 2019/20 | 2468 |
| 2020/21 | 2010 |
| 2021/22 | 2333 |

### 14.2.7 *Catch rate indices*

A standardised catch rate (CPUE) index is available for the historical steam trawl fleet for the years 1919-23, 1937-42, and 1952-57 (Klaer, 2006; Table 14.3). An unstandardised catch rate index for early Danish seine has been used in tiger flathead assessments since Cui *et al.* (2004) (Table 14.4).

Catch and effort data from the SEF1 logbook database were standardised using GLMs to obtain indices of relative abundance (Sporcic 2021b; Table 14.5) from the period 1986-2020 for recent Danish seine, eastern and Tasmanian trawl fleets.

Abundance indices from the Fishery Independent Survey from 2008-2016 were also used, separated into zones 10 and 20, to match the eastern trawl fleet, and zone 30, to match the Tasmanian trawl fleet (Table 14.6). These abundance indices use the FIS3 abundance index (Sporcic et al., 2019) which reconditions the original FIS abundance index, as used in the 2016 assessment and all previous SESSF stock assessments which included FIS abundance indices, and accounts for within year variation in catch rates.

Table 14.3. Standardised catch rates for the steam trawl fleet (Klaer 2006).

| Year | Value | CV |
|---|---|---|
| 1919 | 1.618 | 0.31 |
| 1920 | 1.732 | 0.31 |
| 1921 | 1.806 | 0.31 |
| 1922 | 1.758 | 0.31 |
| 1923 | 1.646 | 0.31 |
| 1937 | 0.635 | 0.31 |
| 1938 | 0.749 | 0.31 |
| 1939 | 0.723 | 0.31 |
| 1940 | 0.611 | 0.31 |
| 1941 | 0.618 | 0.31 |
| 1942 | 0.401 | 0.31 |
| 1952 | 0.262 | 0.31 |
| 1953 | 0.208 | 0.31 |
| 1954 | 0.232 | 0.31 |
| 1955 | 0.219 | 0.31 |
| 1956 | 0.208 | 0.31 |
| 1957 | 0.169 | 0.31 |

Table 14.4. Unstandardised catch rates for the early Danish seine fleet.

| Year | Value | CV |
|---|---|---|
| 1950 | 38.7 | 0.33 |
| 1951 | 27.6 | 0.33 |
| 1952 | 31.8 | 0.33 |
| 1953 | 52.0 | 0.33 |
| 1954 | 34.4 | 0.33 |
| 1955 | 47.4 | 0.33 |
| 1956 | 46.5 | 0.33 |
| 1957 | 32.1 | 0.33 |
| 1958 | 22.5 | 0.33 |
| 1959 | 28.7 | 0.33 |
| 1960 | 43.6 | 0.33 |
| 1965 | 38.2 | 0.33 |
| 1966 | 41.5 | 0.33 |
| 1967 | 62.5 | 0.33 |
| 1968 | 61.2 | 0.33 |
| 1969 | 77.8 | 0.33 |
| 1970 | 67.1 | 0.33 |
| 1971 | 69.9 | 0.33 |
| 1972 | 114.0 | 0.33 |
| 1973 | 88.0 | 0.33 |
| 1974 | 58.1 | 0.33 |
| 1975 | 56.6 | 0.33 |
| 1976 | 41.9 | 0.33 |
| 1977 | 55.5 | 0.33 |
| 1978 | 51.9 | 0.33 |

Table 14.5. Standardised catch rates for the Danish seine, eastern and Tasmanian diesel trawl fleets from 1986-2018. The coefficient of variation is initially set at a value equal to the root mean squared deviation from a loess fit (Sporcic, 2021a, Sporcic 2021b).

| Year | Fleet | | | | | |
|---|---|---|---|---|---|---|
| | D Seine | CV | E Trawl | CV | Tas Trawl | CV |
| 1986 | 1.1600 | 0.170 | 0.8046 | 0.143 | 0.9589 | 0.189 |
| 1987 | 1.6316 | 0.170 | 1.0722 | 0.143 | 0.5620 | 0.189 |
| 1988 | 1.7890 | 0.170 | 1.1740 | 0.143 | 0.9849 | 0.189 |
| 1989 | 1.5506 | 0.170 | 1.1741 | 0.143 | 0.7217 | 0.189 |
| 1990 | 1.0414 | 0.170 | 1.3964 | 0.143 | 0.7263 | 0.189 |
| 1991 | 1.4126 | 0.170 | 1.3118 | 0.143 | 0.6821 | 0.189 |
| 1992 | 1.5151 | 0.170 | 1.0357 | 0.143 | 0.6524 | 0.189 |
| 1993 | 0.9376 | 0.170 | 1.0502 | 0.143 | 0.6081 | 0.189 |
| 1994 | 0.8076 | 0.170 | 0.7624 | 0.143 | 0.6355 | 0.189 |
| 1995 | 0.8295 | 0.170 | 0.8049 | 0.143 | 0.7174 | 0.189 |
| 1996 | 0.7771 | 0.170 | 0.7196 | 0.143 | 0.6519 | 0.189 |
| 1997 | 1.0101 | 0.170 | 0.7199 | 0.143 | 0.8053 | 0.189 |
| 1998 | 0.8502 | 0.170 | 0.7611 | 0.143 | 0.9640 | 0.189 |
| 1999 | 1.2371 | 0.170 | 0.9197 | 0.143 | 1.0797 | 0.189 |
| 2000 | 0.9221 | 0.170 | 1.0110 | 0.143 | 0.8747 | 0.189 |
| 2001 | 0.8649 | 0.170 | 0.9704 | 0.143 | 0.7383 | 0.189 |
| 2002 | 1.0208 | 0.170 | 1.0535 | 0.143 | 1.3196 | 0.189 |
| 2003 | 1.0597 | 0.170 | 1.0396 | 0.143 | 1.3586 | 0.189 |
| 2004 | 1.0418 | 0.170 | 0.9042 | 0.143 | 1.8548 | 0.189 |
| 2005 | 1.0551 | 0.170 | 0.7789 | 0.143 | 1.6896 | 0.189 |
| 2006 | 1.0383 | 0.170 | 0.9428 | 0.143 | 1.3682 | 0.189 |
| 2007 | 1.2495 | 0.170 | 1.1483 | 0.143 | 1.1167 | 0.189 |
| 2008 | 1.1203 | 0.170 | 1.2105 | 0.143 | 1.0469 | 0.189 |
| 2009 | 1.1575 | 0.170 | 1.1215 | 0.143 | 1.0185 | 0.189 |
| 2010 | 1.0486 | 0.170 | 1.0799 | 0.143 | 1.0148 | 0.189 |
| 2011 | 0.9719 | 0.170 | 1.0645 | 0.143 | 0.9582 | 0.189 |
| 2012 | 0.9248 | 0.170 | 1.1676 | 0.143 | 1.2184 | 0.189 |
| 2013 | 0.6676 | 0.170 | 0.8824 | 0.143 | 1.1774 | 0.189 |
| 2014 | 0.7186 | 0.170 | 1.0361 | 0.143 | 1.3689 | 0.189 |
| 2015 | 0.7132 | 0.170 | 1.1682 | 0.143 | 1.2842 | 0.189 |
| 2016 | 0.7418 | 0.170 | 1.0666 | 0.143 | 1.0493 | 0.189 |
| 2017 | 0.7159 | 0.170 | 0.8804 | 0.143 | 1.1820 | 0.189 |
| 2018 | 0.5127 | 0.170 | 0.8825 | 0.143 | 0.8325 | 0.189 |
| 2019 | 0.4662 | 0.170 | 0.9411 | 0.143 | 0.8498 | 0.189 |
| 2020 | 0.4392 | 0.170 | 0.9436 | 0.143 | 0.9287 | 0.189 |

Table 14.6. FIS3 derived abundance indices for tiger flathead with corresponding coefficient of variation (cv) eastern trawl fleet (zones 10 and 20); and Tasmanian trawl fleet (zone 30). The coefficient of variation is initially set at a value equal to the root mean squared deviation from a loess fit (Sporcic, 2019a, Sporcic 2019b).

| Year | FIS East | | FIST Tas | |
|---|---|---|---|---|
| | Z 10, 20 | CV | Z 30 | CV |
| 2008 | 11496.27 | 0.23 | 6019.18 | 0.07 |
| 2010 | 8585.84 | 0.23 | 7868.28 | 0.07 |
| 2012 | 16344.18 | 0.23 | 7808.31 | 0.07 |
| 2014 | 9574.55 | 0.23 | 9102.49 | 0.07 |
| 2016 | 8500.62 | 0.23 | 12961.75 | 0.07 |

In this stock synthesis assessment, the coefficient of variation for the more recent abundance indices (CPUE from recent Danish seine, eastern and Tasmanian trawl fleets and both FIS3 abundance series) is initially set to a value equal to the root mean squared deviation from a loess fit (Sporcic, 2021a, 2021b) and additional variance is estimated for each abundance index to tune the input and output variances.

#### 14.2.8 *Model structure for projected catch scenarios*

The same model structure and assumptions described in the 2019 assessment (Day, 2019) are used for the projected catch scenarios presented here. Changes include updating to the latest version of Stock Synthesis, SS-V3.30.17.00 (Methot et al., 2021), using preliminary catches for 2019, 2020 and 2021 and updating the Danish seine, eastern trawl and Tasmanian trawl CPUE series up to the end of 2020. All other data used (discard estimates, length composition data, conditional age-at-length data, ageing error matrix) in these projected catch scenarios are identical to those data used in the 2019 assessment.

## *14.3 Alternative catch scenarios*

#### 14.3.1 *Update catch from 2017 to 2021 and update CPUE to 2020*

Initial data updates to the 2019 base case model were performed in a stepwise manner, with four scenarios considered in this data update section.

1. 2019 base case (FLT2019)
2. Update from SS- V3.30.14.05to SS-V3.30.17.00
3. Update catch to 2020 (FLT2021UpdateCatch)
4. Update CPUE to 2020, with updated catch retained (FLT2021CatchRBC)
5. Update CPUE to 2020, with updated catch retained, with fixed projected catches at 2,400t (including both retained and estimated discarded catch) from 2022-2025 (FLT2021Catch2400)

Under the first four scenarios, projections are made under average recruitment, with future (projected) catches set to the RBC. The first two scenarios, based on the 2019 base case, project catches from 2020 onwards, set to the RBC. Scenarios 3 and 4, which feature fixed catches until 2021, project catches from 2022 onwards at the RBC. Scenario 5, which also feature fixed catches until 2021, project catches from 2022 onwards, with the total catch (retained plus discarded) set to 2400 t from 2022-2025 and then set to the RBC from 2026 onwards.

The update to SS-V3.30.17.00 (scenario 2) made no discernible difference, so the results of this scenario are not shown here. Similarly, the difference for scenario 3 made little difference, so are not shown here.

The values of the projected catches for scenarios 1, 4 and 5, and the subsequent (calculated) RBC, are listed in Table 14.7 for the period 2020-2025. These values are calculated from 2020 onwards, for the 2019 base case, and calculated or fixed from 2022 onwards, for the scenario with updated catch and CPUE, with all calculated values shown in bold in Table 14.7. Similarly the calculated stock status at the beginning of each year from 2020-2025, assuming average recruitment, is shown in Table 14.8 and

displayed in Figure 14.5, showing the relative stock status over the full time series from 1915-2025 and in Figure 14.6, showing the relative stock status from 2010-2025.

Table 14.7. Fixed and RBC catch projections (including discards) for 2020-2025 after applying these projected catches (under average recruitment) for the 2019 base case, the 2021 updated catch and CPUE scenario, and the 2021 updated catch and CPUE scenario with fixed catch projections. RBC catch projections are shown in bold.

| | Catch | | |
|---|---|---|---|
| Year | FLT2019 | FLT2021CatchRBC | FLT2021Catch2400 |
| 2020 | **2,334** | 2,428 | 2,428 |
| 2021 | **2,648** | 2,423 | 2,281 |
| 2022 | **2,706** | **2,593** | 2,400 |
| 2023 | **2,755** | **2,675** | 2,400 |
| 2024 | **2,796** | **2,730** | 2,400 |
| 2025 | **2,830** | **2,777** | 2,400 |

Table 14.8. Projected stock status for 2020-2025 following application of fixed and RBC catch projections (including discards) for 2020-2025 after applying these projected catches and RBCs from Table 14.7 (from average recruitment) for the 2019 base case, the 2021 updated catch and CPUE scenario, and the 2021 updated catch and CPUE scenario with fixed catch projections.

| | Stock status (%) | | |
|---|---|---|---|
| Year | FLT2019 | FLT2021CatchRBC | FLT2021Catch2400 |
| 2020 | 33.7 | 32.2 | 32.2 |
| 2021 | 35.2 | 33.5 | 33.5 |
| 2022 | 36.1 | 34.9 | 35.2 |
| 2023 | 36.8 | 35.9 | 36.7 |
| 2024 | 37.4 | 36.7 | 38.0 |
| 2025 | 37.9 | 37.3 | 39.3 |

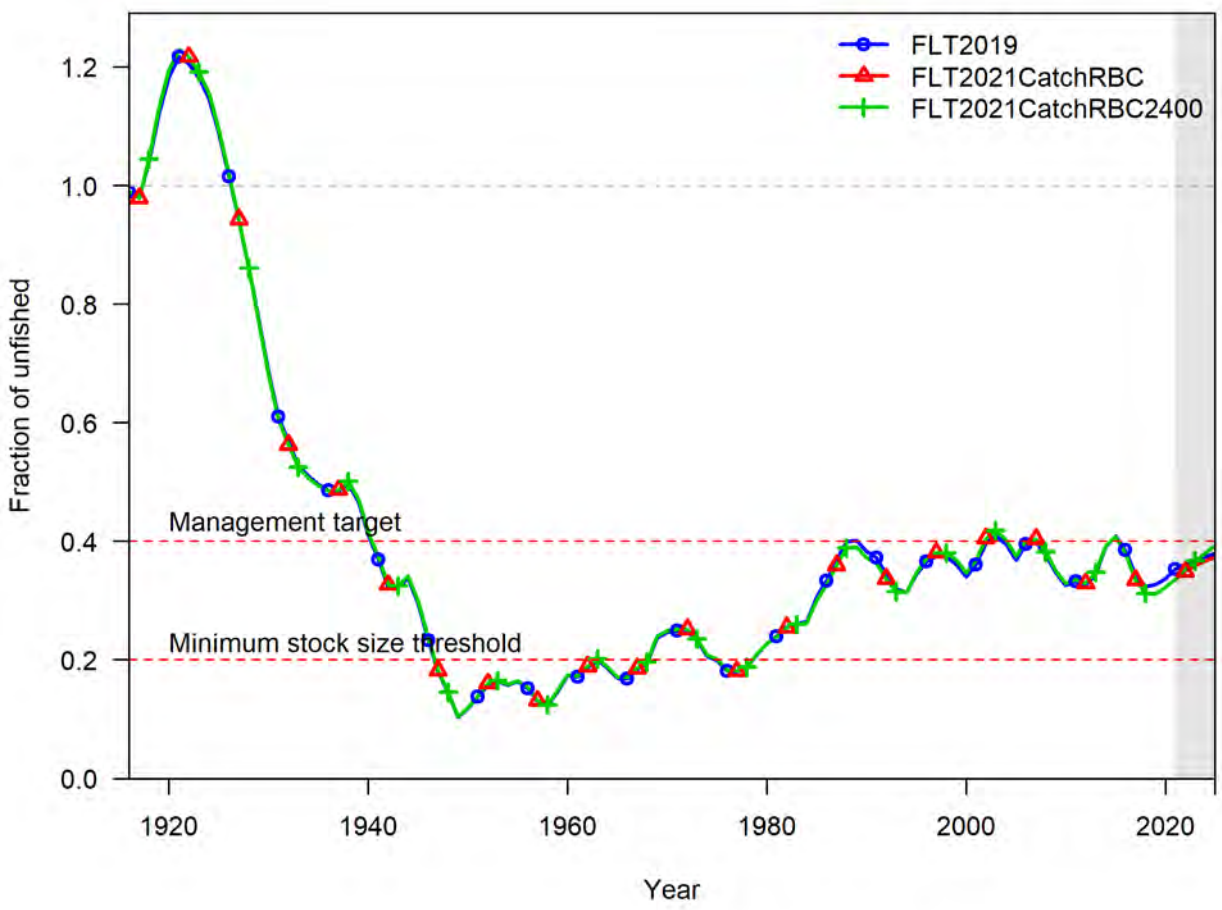


Figure 14.3. Relative spawning biomass (1915-2025) for the 2019 base case, the 2021 updated catch and CPUE scenario, and the 2021 updated catch and CPUE scenario with fixed catch projections.

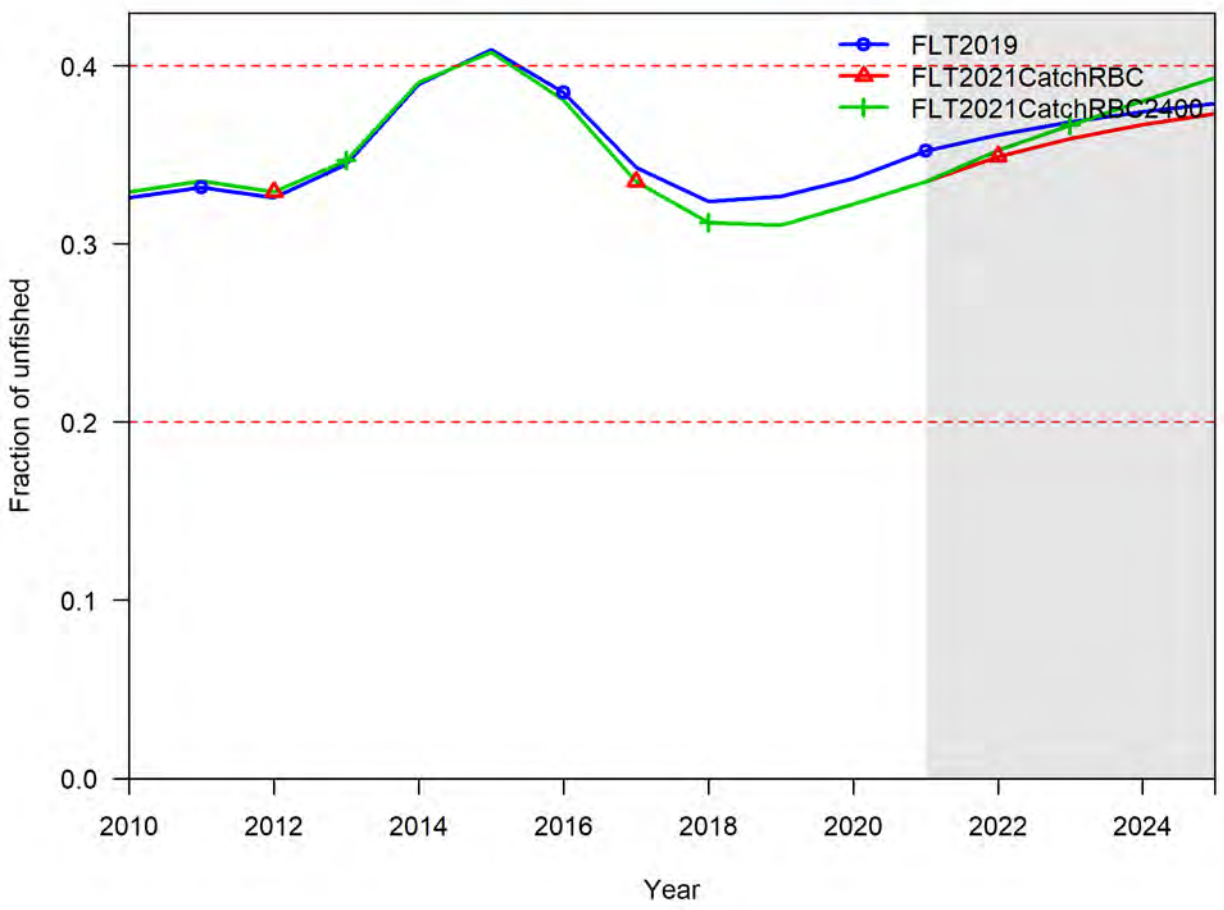


Figure 14.4. Relative spawning biomass (2010-2025) for the 2019 base case, the 2021 updated catch and CPUE scenario, and the 2021 updated catch and CPUE scenario with fixed catch projections.

Recruitment deviations for the 2019 base case, the 2021 updated catch and CPUE scenario, and the 2021 updated catch and CPUE scenario with fixed catch projections are shown in Figure 14.7. This shows that recruitment is set to average recruitment from 2016 for all three scenarios. Note that the recent estimated recruitment events are revised downwards, and more so in 2016, with the addition of the updated CPUE. This revision to the recruitment is influenced by the updated CPUE, which shows a decline in the most recent data for the Danish seine fleet, with subsequent improvements to the fit to the updated CPUE.

Updating both the catch data and CPUE results in minor changes to predicted spawning biomass. The relative stock status in 2023 is 37% for scenario 1 (after applying the RBC, given the projected stock status) compared to 36% for scenario 4 (catch and CPUE updated). The relative stock status in 2024 is 38% for scenario 1 (after applying the RBC, given the projected stock status) compared to 37% for scenario 4 (catch and CPUE updated).

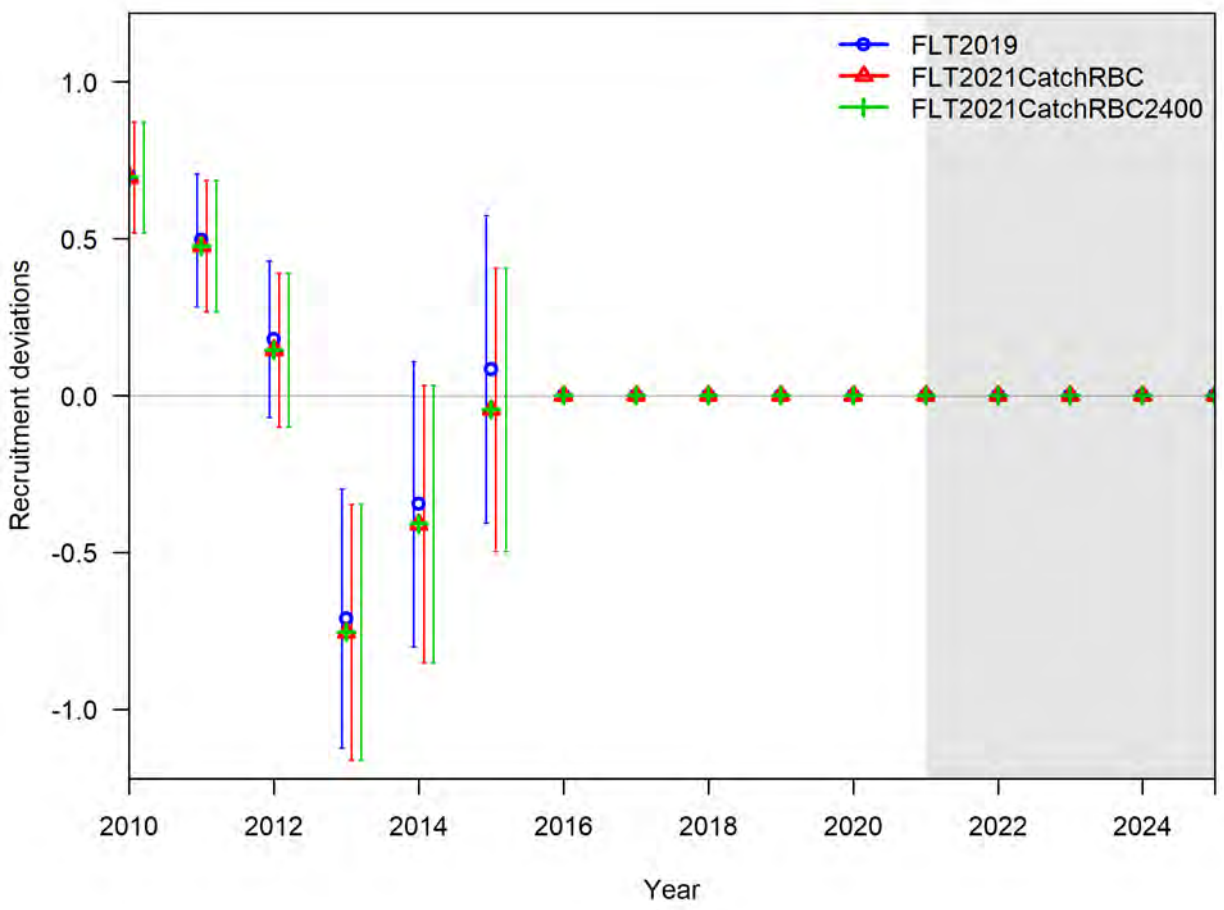


Figure 14.5. Recruitment deviations (2010-2023) for the 2017 base case, the updated catch and updated CPUE scenarios (showing average recruitment).

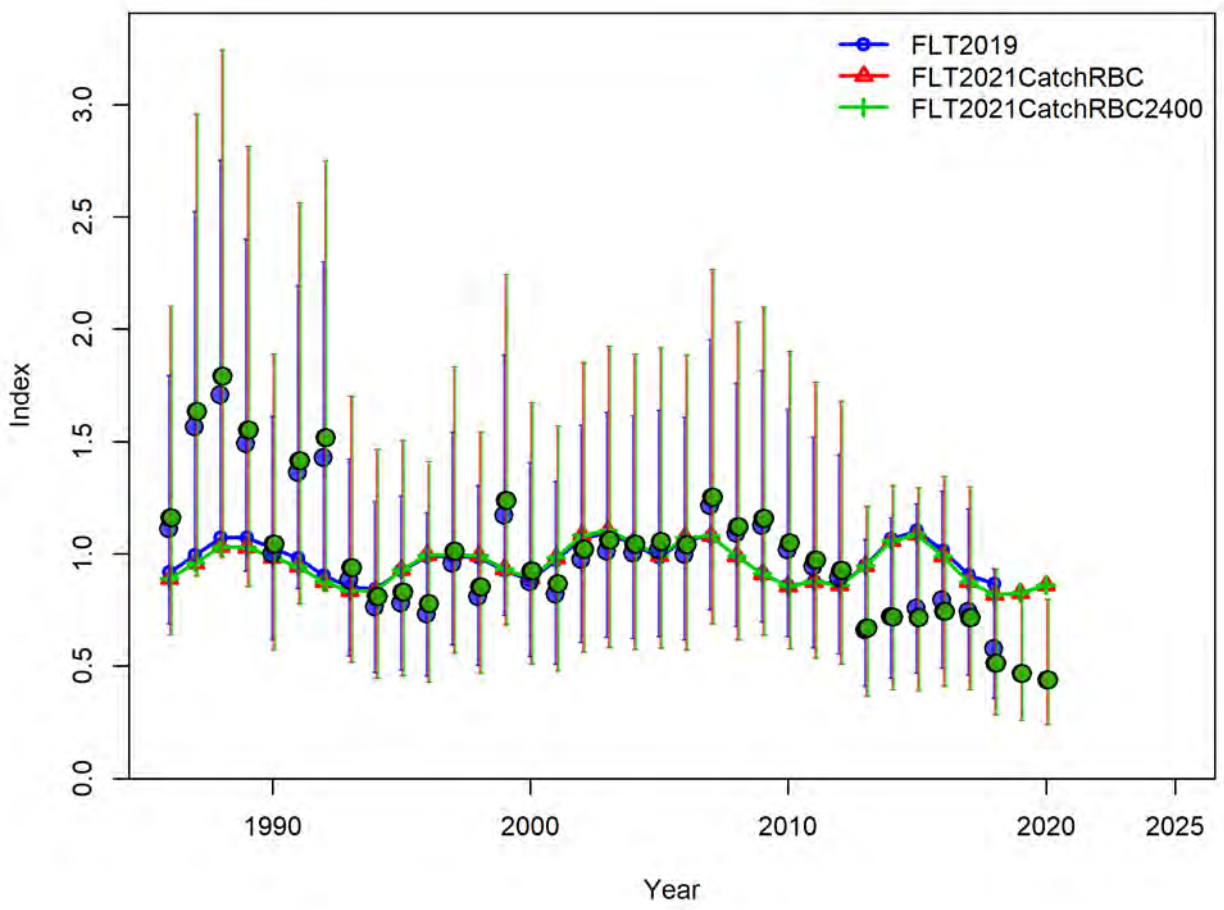


Figure 14.6. Fits to the Danish seine CPUE series for the 2019 base case, the 2021 updated catch and CPUE scenario, and the 2021 updated catch and CPUE scenario with fixed catch projections.

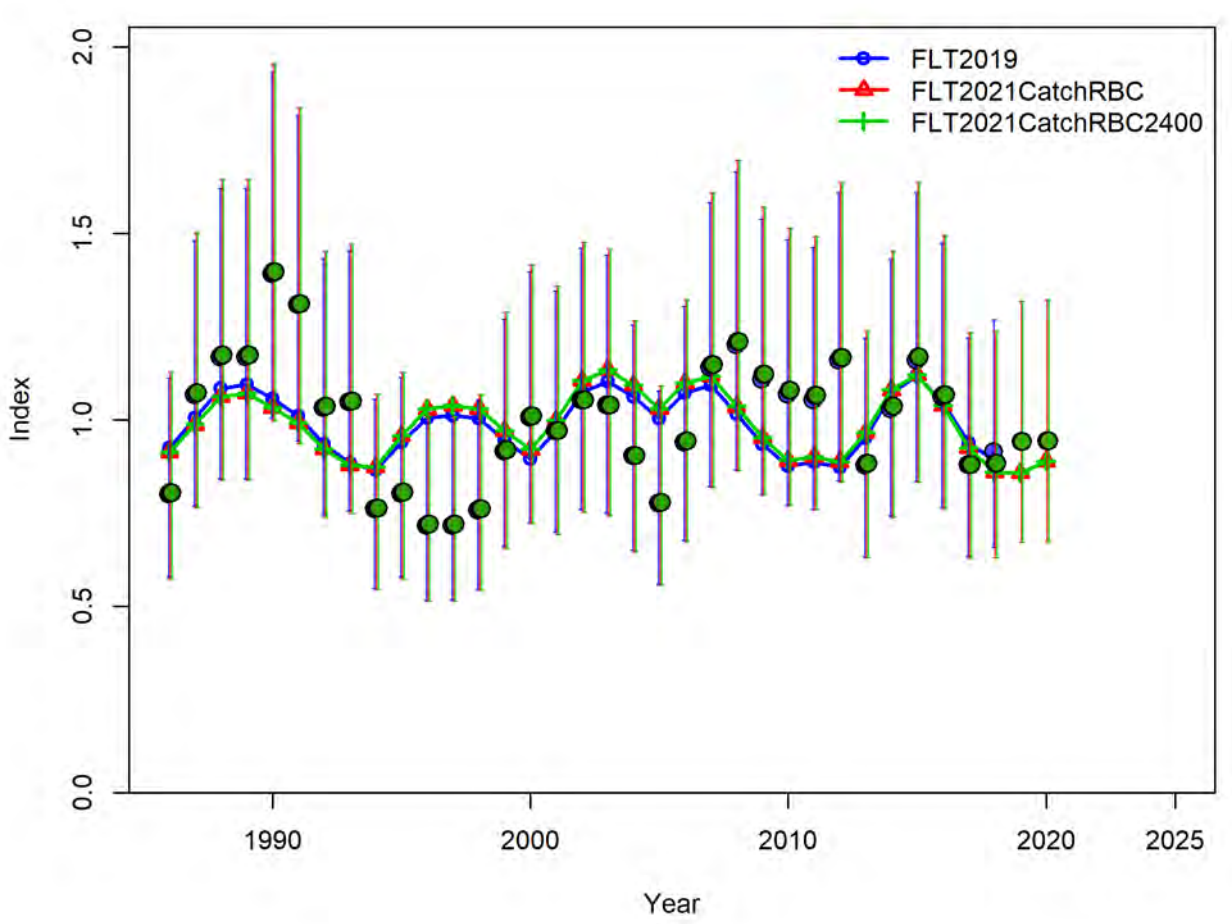


Figure 14.7. Fits to the eastern trawl CPUE series for the 2019 base case, the 2021 updated catch and CPUE scenario, and the 2021 updated catch and CPUE scenario with fixed catch projections.

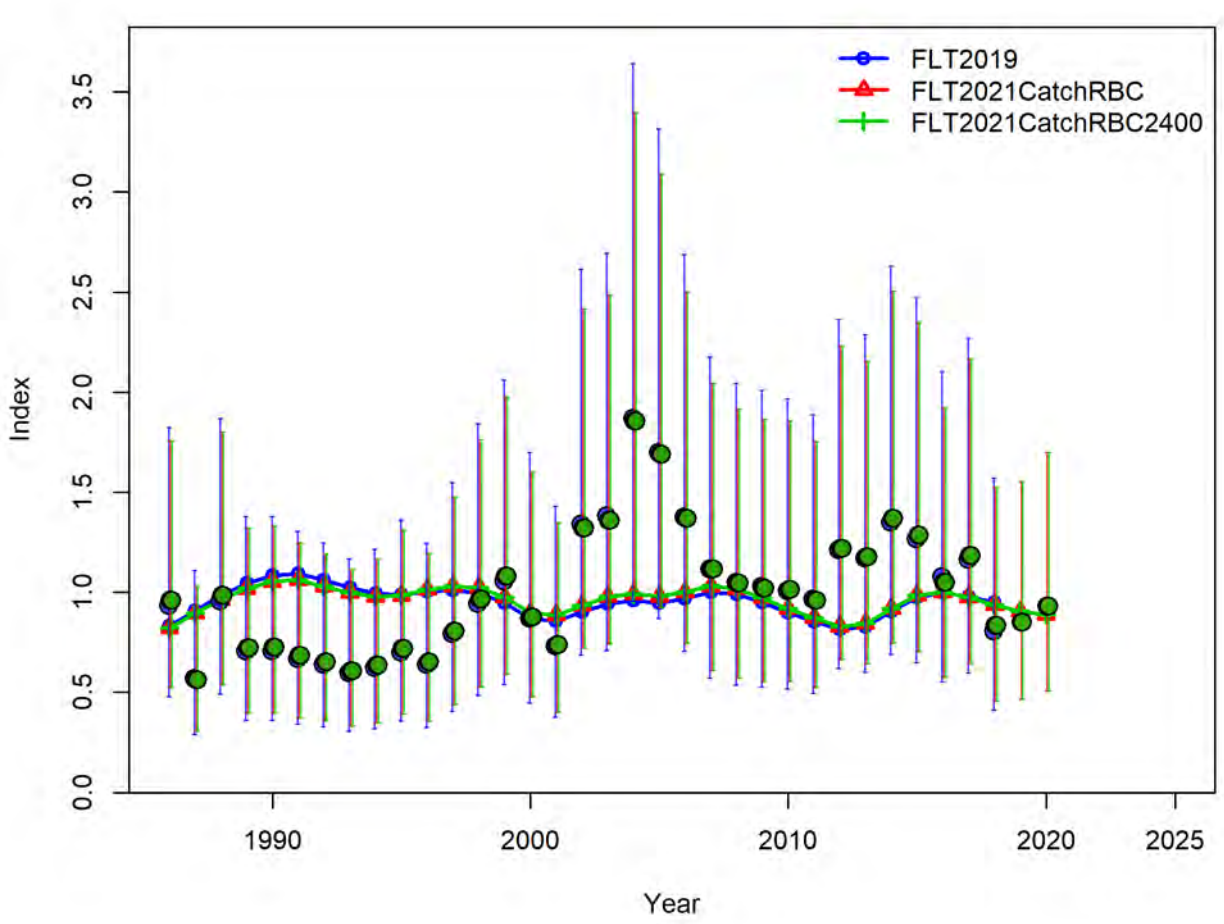


Figure 14.8. Fits to the Tasmanian trawl CPUE series for the 2019 base case, the 2021 updated catch and CPUE scenario, and the 2021 updated catch and CPUE scenario with fixed catch projections.

## *14.4 Acknowledgements*

Age data was provided by Kyne Krusic-Golub (Fish Ageing Services), ISMP and AFMA logbook and CDR data were provided by John Garvey (AFMA). Mike Fuller, Paul Burch, Robin Thomson, Roy Deng, Franzis Althaus, Toni Cannard and Caroline Sutton (CSIRO) were all involved in pre-processing the data. Malcolm Haddon provided useful code for auto-balancing, Athol Whitten provided R code for organising plots. Geoff Tuck, Pia Bessell-Browne and Miriana Sporcic are thanked for helpful discussions on this work.

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# 15. Benefits

The results of this project have had a direct bearing on the management of the Southern and Eastern Scalefish and Shark Fishery. Direct benefits to the commercial fishing industry in the SESSF have arisen from improvements to, or the development of, assessments under the various Tier Rules of the Commonwealth Harvest Strategy Policy for selected quota and non-quota species. Information from the stock assessments has fed directly into the TAC setting process for SESSF quota species. As specific and agreed harvest strategies are being developed for SESSF species (a process required by and agreed to under EPBC approval for the fishery), improvements in the assessments developed under this project have had direct and immediate impacts on quota levels or other fishery management measures (in the case of non-quota species).

Participation by the project's staff on the SESSF Resource Assessment Groups has enabled the production of critical assessment reports and clear communication of the reports' results to a wide audience (including managers, industry). Project staff's scientific advice on quantitative and qualitative matters is also clearly valued.

The stock assessments presented in this report have provided managers and industry greater confidence when making key commercial and sustainability decisions for species in the SESSF. These assessments have provided the most up-to-date information, in terms of data and methods, to facilitate the management of the Southern and Eastern Scalefish and Shark Fishery.

# 16. Conclusion

The 2021 assessment of the stock status of key Southern and Eastern Scalefish and Shark fishery species is based on the methods presented in this report. Documented are the latest quantitative assessments (Tier 1) for key quota species (Blue Grenadier, Silver Warehou, Eastern Jackass Morwong and Eastern Zone Orange Roughy), projection updates for School Whiting and Tiger Flathead, as well as CPUE standardisations for shelf, slope, deepwater and shark species, Tier 4 and Tier 5 analyses. Typical assessment outputs provided indications of current stock status and an application of the Commonwealth Harvest Strategy framework. This framework is based on a set of assessment methods and associated harvest control rules, with the decision to apply a particular combination dependent on the type and quality of information available to determine stock status (Tiers 1 to 5).

The assessment outputs from this project are a critical component of the management and TAC setting process for these fisheries. The results from these studies are being used by SESSFRAG, industry and management to help manage the fishery in accordance with agreed sustainability objectives.

**Stock status and Recommended Biological Catch (RBC) conclusions (Tier 1):**

For Blue Grenadier, the estimated virgin female spawning biomass ($SSB_0$) is 37,445 tonnes and the projected 2022 spawning stock biomass will be 155% of $SSB_0$ (projected assuming 2020 catches in 2021). The 2022 recommended biological catch (RBC) under the 20:35:48 harvest control rule is 23,777 t, with 245 t estimated discards (23,532 t retained). The long-term RBC is 7,100 t, with 183 t discards.

For Eastern Jackass Morwong, the base-case assessment estimates that the projected 2022 spawning stock biomass will be 15% of $SSB_0$, with recruitment from 2016 onwards projected using a low recruitment scenario, using the average of the ten most recently estimated recruitment deviations, from 2006-2015. Under the agreed 20:35:48 harvest control rule, the 2022 RBC is 0 t, with the long-term yield (assuming low recruitment in the future) of 91 t.

For Eastern Orange Roughy, the median estimate of $SSB_0$from the MCMC analysis was 38,924 t, slightly lower than the MPD estimate of 40,479 t. The current 2022 female spawning biomass is estimated to be 11,644 t from the MCMC and 13,126 t from the MPD. Relative spawning biomass in 2022 is estimated at 30.0% of unfished levels from the MCMC and 32.4% of unfished levels from the MPD. The RBC for 2022 from the MCMC analysis is 681 t, lower than the MPD estimate for 2022 of 944 t. The average RBC over the next three years (2022-2024) is 737 t from the MCMC analysis and 1,025 t from the MPD.

For Silver Warehou, the assessment estimates that the projected 2022 stock status will be 29% of$SSB_0$, projected assuming 2020 catches in 2021, with recruitment from 2016 onwards assumed to be below average, fixed at the average of 2011-2015 levels. The assessment suggests that stock status was as low as 21% of $SSB_0$ in 2016. Under the 20:35:48 harvest control rule, the 2022 RBC is 587 t, while the long-term yield (assuming continuation of low recruitment) is 591 t.

For School Whiting, if the default (proxy) target reference point (48%) used in the SESSF harvest control rule, and specifically as used by AFMA for School Whiting, is reduced to 40%, a modified 20:35:40 harvest control rule can be applied. This lower target allows the stock to be fished to a lower target biomass (40% of $SSB_0$). Under a revised 40% target, the 2021 RBC would be 2,753 t.

For Tiger Flathead, updates to catch and CPUE resulted in a revision downwards to the 2020 stock status, from 34% in the last stock assessment to 32% in this analysis. These changes are due to revisions to the catches (2017-2021) and to the revised CPUE series, which has a downturn at the end of the time series (2019-2020) for the Danish seine CPUE. The eastern trawl and Tasmanian trawl CPUE series do not show the same downturn at the end of the CPUE series as Danish seine, with both trawl CPUE relatively flat in the period 2019-2020. Projecting forward to 2022 takes the stock status to 35% at the start of 2022, and this is expected to recover to 37% at the start of 2025, assuming that the RBC is caught in 2023 and 2024 and there is average recruitment from 2017 onwards

# 17. Appendix: Intellectual Property

No intellectual property has arisen from the project that is likely to lead to significant commercial benefits, patents or licenses.

# 18. Appendix: Project Staff

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