Australia's National
Science Agency

Tier 4 assessment for Western Deepwater Sharks in the SESSF (data to 2022)

Prepared for SERAG No. 2 Meeting

2-3 November 2023

M. Sporcic

25 October 2023

Citation

Sporcic, M. (2023). Tier 4 Assessment for Western Deepwater Sharks in the SESSF (data to 2022). Technical paper presented to the SERAG, 2 - 3 November 2023. CSIRO Environment, Hobart. 17 p.

Table of Contents

Acknowledgements

Thanks goes to the CSIRO database team for their processing of the catch and effort (CPUE) and Catch Disposal Record (CDR) data as received from the Australian Fisheries Management Authority. Geoff Tuck (CSIRO) and Pia Bessell-Browne (CSIRO) are also thanked for reviewing this report.

1 Executive Summary

A traditional Tier 4 assessment was performed for the following species and/or fisheries:

- Western Deepwater Sharks

<u>Western Deepwater Sharks:</u> The 2023 estimated RBC is 326.7 t, an increase of 92.7 t compared to the 2018 estimated RBC (235 t; see Sporcic 2018). The increase in RBC of approximately 93 t can be mostly attributed to an increase in the most recent CPUE and hence the mean of the most recent four-year average which is used to calculate the RBC. Also, the CPUE in 2023 is above the CPUE target based on the Tier 4 Harvest Control Rule (0.62) and has been above target since 2015.

2 Introduction

2.1 Tier 4 Harvest Control Rule

The Tier 4 harvest control rules are the default procedure applied to species which only have catches and catch per unit effort (CPUE) data available; specifically, there is no other reliable information on either current biomass levels or current exploitation rates.

Ideally, in line with the notion of being more precautionary in the absence of information, the outcome from these analyses should be more conservative than those available from higher Tier analyses; this is now explicitly implemented by imposing a 15% discount factor on the Tier 4 RBC as a precautionary measure unless there are good reasons for not imposing such a discount on particular species. The application of the discount factor will occur unless RAGs generate explicit advice that alternative equivalent precautionary measures are in place (such as spatial or temporal closures) or that there is evidence of historical stability of the stock at current catch levels (AFMA, 2009).

Tier 4 analyses require as a minimum, a time series of total catches and of standardized CPUE, along with an agreed reference period and reference points.

The current Tier 4 analysis and control rule underwent Management Strategy Evaluation (Wayte, 2009; Little et al., 2011a), which demonstrated its advantages over an earlier implementation used in 2007 and 2008. Further work has since demonstrated that as long as there is a limit on increases and decreases to the RBC of no more than 50 % then the notion of including a maximum RBC (at 1.25 times the target) is redundant (Little et al., 2011b).

2.2 Tier 4 Assumptions

2.2.1 Informative CPUE

There is a linear relationship between CPUE and exploitable biomass. If there is hyper-stability (CPUE remain stable while stock size changes) or hyper-depletion (CPUE decline much faster than stock size changes) then the standard Tier 4 analysis would provide biased results.

2.2.2 Consistent CPUE Through Time

The character of the estimated CPUE has not changed in significant ways through the period from the start of the reference period to the end of the most recent year. If there has been significant effort creep altering the catchability, or there have been changes to the fleet that have altered the relative efficiency of the vessels fishing, or the catchability of the species by the fleet has been altered by other changes then the comparability of recent CPUE with the target period may be compromised. Such changes would reduce the responsiveness of the Tier 4 method to change and may generate inappropriate management advice. Included in this clause are the effects of targeting or not targeting aggregated species. When CPUE is extremely variable through time, such that mean estimates become unreliable measures of stock status, then the Tier 4 approach cannot be validly applied.

2.2.3 Plausible Target Reference Period

The reference period provides an estimate of the stock when at a depletion level of 48% unfished spawning biomass. The Tier 4 method is based on CPUE and thus relates to exploitable biomass and not spawning biomass. As a minimum the reference period will refer to a period when the stock was in an acceptable, productive and sustainable state. But there can be no guarantees that the target aimed for is really $B_{48\%}$. The traditional Tier 4 assessment assumes CPUE is proportional to abundance under the following two rules:

- If the CPUE series is available for the entire catch history, then the assumption is that the initial years of CPUE correspond to an unexploited biomass and therefore the target CPUE is defined as 50% of the initial CPUE.
- If the CPUE series is not available for the entire catch history, then a period of stability is chosen as the reference period and the target CPUE is the average of the CPUE during this period.

The above first rule is assumed for Western Deepwater Sharks.

2.2.4 Accurate Total Catch History

Accurate estimates are required for all catches from the stock under consideration during the accepted target period, irrespective of what method was used or whether it was retained or discarded. This assumption is especially vulnerable to being breached when large proportions of catches are discarded. While there is a procedure for adjusting the standardized CPUE for these missed catches the uncertainty over the actual amount of harvested fish remains.

2.2.5 Some Implications of the Assumptions

The outcomes of Tier 4 assessments should not be regarded with the same confidence as those from Tier 1 assessments. Even though they are termed stock assessments, they are empirical analyses of catches and CPUE. Any uncertainty in the catch or CPUE time series is propagated directly through to the outputs of the analysis. For quota species the catches and reported CPUE is usually relatively well founded because of the quota catch disposal records and other compliance requirements. However, where there is a relatively high degree or variable discarding of catches this can lead to much greater levels of uncertainty. The assessments for those species that are conducted using a Tier 4 method should be reviewed for their inter-annual consistency and how the fishery has been responding to the management advice derived from the Tier 4 assessments.

3 Western Deepwater Shark

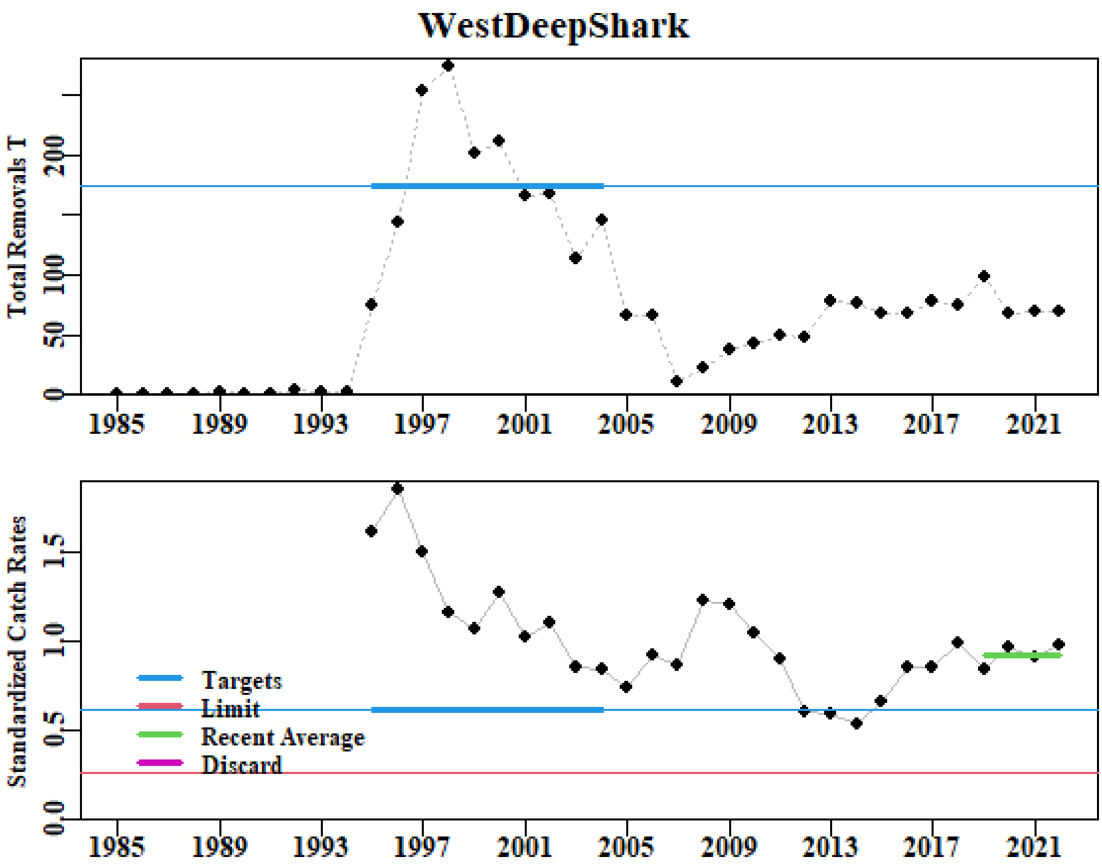

Figure 1: Western Deepwater Shark. Top plot is the total removals with the fine line illustrating the target catch. Bottom plot represents the standardized CPUE with the upper fine line representing the target CPUE and the lower line the limit CPUE. Thickened lines represent the reference period for catches, CPUE, and the recent average CPUE.

Table 1: Western Deepwater Shark RBC calculations. C_{targ} (t) and $CPUE_{targ}$ (CE_Target) are the targets identified in the figure above, $CPUE_{Lim}$ (CE_Limit) is 20% of the B_0 proxy (which relate to the $CPUE_{targ}$), and the most recent CPUE is the average CPUE over the last four years. Recommended Biological Catch (RBC).

Parameter	Value	Parameter	Value
Reference_Years	1995 - 2004	Scaling	1.8673
CE_Target	0.6157	Previous TAC (t)	235
CE_Limit	0.2565	C_{targ}	174.963
CE_Recent	0.9272	RBC (t)	326.715

Table 2: Western Deepwater Shark data for the Tier 4 calculations. Total (t) is the sum of Discards, State, Non Trawl and SEF2 catches where applicable. All values in Tonnes. CE is the standardized CPUE (Sporcic, 2023). GeoMean is the geometric mean CPUE.

Year	Catch	Total	State	CE	GeoMean	TAC
1985	0.130	0.130				-
1986	0.970	0.970				-
1987	0.545	0.545				-
1988	0.105	0.105				-
1989	1.490	1.490				-
1990	0.000	0.000				-
1991	0.480	0.480				-
1992	3.780	3.780				-
1993	1.995	1.995				-
1994	1.552	1.552				-
1995	75.219	75.219		1.6182	1.4934	-
1996	143.247	143.247		1.8530	1.6186	-
1997	253.317	253.317		1.5064	1.4975	-
1998	273.775	273.775		1.1621	1.1584	-
1999	201.927	201.927		1.0707	1.0172	-
2000	210.945	210.945		1.2810	1.2714	-
2001	165.234	165.234		1.0229	1.0414	-
2002	167.597	167.597		1.1031	1.2149	-
2003	113.530	113.530		0.8579	0.8073	-
2004	144.842	144.842		0.8389	0.9041	-
2005	66.806	66.806		0.7382	0.8153	108
2006	65.480	65.480		0.9167	0.9405	108
2007	10.269	10.269		0.8642	0.7709	10
2008	22.257	22.257		1.2259	1.0333	50
2009	37.634	37.634		1.2122	1.0575	63
2010	42.093	42.093		1.0453	1.0091	95
2011	49.623	49.623		0.9014	0.8880	143
2012	47.228	47.228		0.6024	0.6337	215
2013	78.248	78.248		0.5927	0.6014	215
2014	76.643	76.643		0.5308	0.5368	215
2015	68.295	68.295		0.6565	0.6862	215
2016	67.256	67.256		0.8484	0.9203	215
2017	78.473	78.473		0.8492	0.9566	215
2018	73.896	73.896		0.9932	1.0616	264
2019	98.600	98.600		0.8467	0.8961	235
2020	67.700	67.700		0.9719	1.0333	235
2021	69.800	69.800		0.9110	1.0656	235
2022	70.100	70.100		0.9793	1.0696	235

3.1.1 Discussion

Western Deepwater Sharks have similar issues to the Eastern Deepwater Sharks regarding the codes used to report their catches. Thus the primary species code used relates to 'Pearl Shark' (a combination of *Deania calcea* and *D. quadrispinosa* = 37020905) followed by 'Other Sharks' (37990003) (see Sporcic 2023). The Platypus Shark is *Deania quadrispinosa*, which is included as one of the components of the 'Pearl Shark', which suggests that the reliability of the species identities may not be high as taxonomically separating these species is not always straightforward. Catches in this assessment are based on open areas only. Discards were not used in this assessment as agreed by SERAG (26-27 September 2023) given there is currently only one available estimate in 2018 and it also differs from the corresponding logbook recorded estimate.

The 2023 estimated RBC is 326.7 t, an increase of 92.7 t compared to the 2018 estimated RBC (235 t; see Sporcic 2018). The increase in RBC of approximately 93 t can be mostly attributed to an increase in the most recent CPUE and hence the mean of the most recent four-year average which is used to calculate the RBC. Also, the CPUE in 2023 is above the CPUE target based on the Tier 4 Harvest Control Rule (0.62) and has been above target since 2015.

4 References

AFMA (2009). SESSF Stock Assessment Methods and TAC Setting Process Version 1.5. 8p.

AFMA (2017). *Southern and Eastern Scalefish and Shark Fishery Management Arrangements Booklet 2017* Australian Fisheries Management Authority, Canberra, Australia. 92p.

Haddon, M. (2010). Tier 4 Analyses (data from 1986 - 2008. Pp 319 - 369 in Tuck, G.N. (*ed*) *Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery 2009 Part 2.* Australian Fisheries Management Authority and CSIRO Marine and Atmospheric Research, Hobart. 428 p.

Haddon, M. (2014). Catch Rate Standardizations for Selected Species from the SESSF (data 1986-2012) pp 57 275 in Tuck, G.N. (*ed*) (2014) *Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery 2013. Part 2.* Australian Fisheries Management Authority and CSIRO Marine and Atmospheric Research, Hobart. 487 p.

Little, R., Tuck, G.N., Haddon, M., Day, J., Klaer, N., Smith, A.D.M., Thomson, R., Wayte, S. (2009). Developing CPUE targets for the Tier 4 harvest strategy of the SESSF. Pp 233-254 in Tuck, G.N. (*ed*) *Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery: 2008 Part 2.* Australian Fisheries Management Authority and CSIRO Marine and Atmospheric Research, Hobart. 331 p.

Little, L.R., Wayte, S.E., Tuck, G.N., Smith, A.D.M., Klaer, N., Haddon, M., Punt, A.E., Thomson, R., Day, J., Fuller, M. (2011a). Development and evaluation of a cpue-based harvest control rule for the southern and eastern scalefish and shark fishery of Australia. *ICES Journal of Marine Science* 68(8): 1699-1705.

Little, L.R., Wayte, S.E., Tuck, G.N. (2011b). The effects of Cmax on the Tier 4 Harvest Control Rule. Pp 3-9 in Tuck, G.N. (*ed*) *Stock Assessment for the Southern and Eastern Scale-fish and Shark Fishery: 2010 Part 2.* Australian Fisheries Management Authority and CSIRO Marine and Atmospheric Research, Hobart. 419p.

R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Sporcic, M. (2018). Tier 4 Assessments for selected SESSF Species (data to 2017). Technical Report prepared for SERAG Meeting 14-16 November 2018 and the Australian Fisheries Management Authority. CSIRO Oceans and Atmosphere, Hobart. 25 p.

Sporcic, M. (2023). Statistical CPUE standardizations for selected deepwater SESSF Species (data to 2022). Technical report prepared for the MYTAC Meeting, 22 August 2023 and SESSFRAG Meeting, 30-31 August 2023. CSIRO Environment, Hobart. 73 p.

Wayte, S.E. (ed.) 2009. *Evaluation of new harvest strategies for SESSF species.* CSIRO Marine and Atmospheric Research, Hobart and Australian Fisheries Management Authority, Canberra. 137 p.

5 Appendix: General Methods

5.1 Tier 4 Harvest Control Rule

The data required are time series of catches and standardized CPUE. The analyses have been conducted on total catches across the entire SESSF (including State catches, SEF2 landing records, and any discards). For some species, where there is only a single stock and a single primary fishing method, analyses are presented using standardized CPUE data (e.g., Haddon, 2014). For other species, there may be multiple stocks or areas or multiple methods and selecting which time series of CPUE to use in the analyses is not always straightforward. In those cases, the standardized CPUE time series for the method now accounting for the majority of current catch was used.

All data relating to catches and/or discards, from both State waters and SEF2 data sets, were provided by AFMA, with initial processing by the data services Team at CSIRO (Hobart). All CPUE data were derived from the standard commercial catch and effort database processed by the data services Team at CSIRO Hobart.

Standard analyses were set up in the statistical software, R Core Team (2022), which provided the tables and graphs required for the Tier 4 analyses. The data and results for each analysis are presented for transparency. The Tier 4 harvest control rule formulation uses a ratio of current CPUE with respect to the selected limit and target reference points to calculate a scaling factor for the current year. This scaling factor is applied to the target catch to generate an RBC. To generate a TAC, known discards and State catches are first removed and then, if applicable, the 15% discount is applied. The TAC calculations are conducted by AFMA. This report focusses on providing the estimates of the Recommended Biological Catches.

$$\text{Scaling Factor } = SF_t = \max\left(0, \frac{\overline{CPUE} - CPUE_{\mathrm{lim}}}{CPUE_{\mathrm{targ}} - CPUE_{\mathrm{lim}}}\right)$$

$$RBC = C_{\mathrm{targ}} \times SF_t$$

If new data becomes available, for example, more State data has become available this year, or other large changes occur in the CPUE then the RBC could undergo large changes. Such changes are constrained by the following limits:

$$\begin{array}{ll} RBC_y = 1.5RBC_{y-1} & RBC_y > 1.5RBC_{y-1} \\ RBC_y = 0.5RBC_{y-1} & RBC_y < 0.5RBC_{y-1} \end{array}$$

where

1. RBC_y is the RBC in year *y*,
2. $CPUE_{\mathrm{targ}}$ is the target CPUE for the species,
3. $CPUE_{\mathrm{lim}}$ is the limit CPUE for the species = 0.4 * $CPUE_{\mathrm{targ}}$,
4. $\overline{CPUE}$ is the average CPUE over the past *m* years; *m* tends to be the most recent four years,
5. C_{targ} is a catch target derived from a period of historical catch that has been identified as a desirable target in terms of CPUE, catches and status of the fishery, e.g. 1986 – 1995. This is an average of the total removals for the selected reference period, including any discards.

$$C_{\mathrm{targ}} = \frac{\sum_{y=yr1}^{yr2} L_y}{(yr2 - yr1 + 1)}$$

where L_y represents the landings in year *y*.

$$CPUE_{\text{targ}} = \frac{\sum_{y=yr1}^{yr2} CPUE_y}{(yr2 - yr1 + 1)}$$

where $CPUE_y$ is the catch rate in year *y*, *yr2* and *yr1* represent the last and the first years in the reference period respectively.

Percent discards are estimated from ISMP observations from 1998 to the current year. Discards for earlier years, prior to ISMP sampling, are generally estimated by taking the overall average percent discard from 1998 to the 2006 and applying that discard rate to the reported landings for the earlier years. The year 2006 was selected as the final year as discarding practices altered at about that time following the structural adjustment and the introduction of the Harvest Strategy Policy. For Eastern Gemfish the average discard rate was determined for 1998-2002 to allow for the non-target nature of the fishery following 2002. The calculation of the earlier discards is done so that the total catches can be estimated even though only the landed catches are available. To calculate the discards for a given year we used:

$$D_y = \frac{C_y \bar{D}_{98-06}}{(1 - \bar{D}_{98-06})}$$

Discard proportions for the projected year for which the RBC is being calculated are taken as a weighted mean of the previous four years:

$$D_{\text{CUR}} = (1.0\ D_{y-1} + 0.5\ D_{y-2} + 0.25\ D_{y-3} + 0.125\ D_{y-4})/1.875$$

where D_{CUR} is the estimated discard rate for the coming year *y*, D_{y-1} is the discards rate in year *y-1*. The discard rate in year *y* is the ratio of discards to the sum of landed catches plus those discards (this can vary between 0 – 100 %):

$$D_y = \frac{Discard_y}{\left(Catches_y + Discard_y\right)}$$

For each species, reference years were selected by the RAGs to generate estimates of target catches and target CPUE. In addition, a decision was required as to whether the fishery could be considered as fully developed or otherwise. Where a fishery was not con-sidered to be fully developed the target catch rate, $CPUE_{\text{targ}}$, was divided by two as a proxy for expected changes to CPUE as the fishery develops and the resource stock size declines towards the target of 48% unfished biomass.

Plots are given of the total removals illustrating the target catch level. In addition, the standardized CPUE are illustrated with the target CPUE and the limit CPUE. Finally, where the data are available, plots are given of the Total removals contrasted with State removals, and of discards and non-trawl catches.

5.2 The Inclusion of Discards

Some species, especially Redfish (*Centroberyx affinis*) and inshore Ocean Perch (*Helicolenus percoides*), have experienced high levels of discarding but the reported CPUE relate only to the estimated landed weights. In those species where discarding makes up a significant proportion of the catch (in some years more Redfish were discarded than landed and more inshore Ocean Perch tend to be discarded than landed) it is reasonable to ask how the discards would have affected CPUE. This is an important question because standardized commercial CPUE is used in Australian stock assessments as an index of relative abundance (e.g., Haddon, 2014); if ignoring discards leads to a consistent bias this could affect the outcome of the assessments and thus, the assessments should become aware of the effects of discards.

CPUE is used in assessments as an index of relative abundance through time and it is the trends exhibited by the CPUE that are important rather than their absolute values. If the discard levels are relatively constant through time and evenly distributed amongst the fleet, then their inclusion would not be expected to influence the trends in CPUE except to add noise. In all cases the discard rates are estimates based on sub-sampling the fleet of vessels. That the estimates are uncertain can be seen simply by considering the summary data tables in this document; where discards rates are not low they are very variable between years. Redfish provide an extreme where in 1998 the estimate was 2324 t, which was nearly 56% of the total catch, while in 1999 discards estimated at only 69 t, making up on about 5% of the total catch. So in those cases where discard levels are low, adding discards to the estimation of CPUE is not expected to alter outcomes.

For those species, such as Redfish and Ocean Perch, where discard rates are much higher it was decided to include those estimated catches to determine their effect on the outcome of the Tier 4 analyses. In 2010 it was concluded that while the inclusion of discards contributed a great deal of noise to the analyses, for those species where discarding made up significant proportions of the overall catch the discard augmented CPUE should be examined each year as a sensitivity analysis to contrast with the outcome from the un-augmented CPUE (Haddon, 2010).

5.2.1 Analyses Including Discards

Discard rates cannot simply be added to known catches in calculating CPUE. The standardized CPUE is estimated from individual catch and effort records but the estimates of discards are summary estimates for each fishery. While a method for incrementing the standardized CPUE has been developed it should be noted that this ignores all complications relating to unknown aspects of discarding behaviour (e.g., Is the discard rate constant across all catch sizes, across all vessels, across all areas?). This means that including discard catches into the annual catch rate estimates introduces an unknown amount of uncertainty into the analysis. It should also be noted that the discard estimates are highly variable from year to year and derive from relatively small samples of all trips contributing to catches.

The method developed was to find the multiplier needed to adjust ratio mean CPUE and apply that to the standardized CPUE (Haddon, 2010). The ratio mean CPUE require the annual sum of catches for the fishery along with the sum of effort and ratio means calculated for each year. The discard estimates from the fishery can be added to the catch totals and new ratio means calculated and compared. The multiplier needed to make the same changes to the ratio mean CPUE can then be developed and applied to the standardized CPUE.

The ratio mean is simply the sum of all catches divided by the sum of effort

$$\hat{I}_{R,t} = \frac{\sum C_t}{\sum E_t}$$

where $\hat{I}_{R,t}$ is the ratio mean CPUE for year t, $\sum C_t$ is the sum of landed catches in year t, and $\sum E_t$ is the sum of effort (as hours trawled) in year t. If $\sum D_t$ is the sum of discards in year t then the discard incremented ratio mean CPUE would be:

$$\hat{I}_{D,t} = \frac{\sum C_t + \sum D_t}{\sum E_t}$$

The same values of $\hat{I}_{D,t}$ can also be obtained using the following multiplier:

$$\hat{I}_{D,t} = [(\sum D_t / \sum C_t) + 1] \times I_t$$

where I_t is the CPUE estimate to be modified by the inclusion of discards. If this is the ratio mean then the augmented CPUE would be identical to the first equation dealing with $\sum D_t$. In practice, the CPUE used with the multiplier are the standardized CPUE (e.g. Haddon, 2014).

5.2.2 The Limitations of Including Discards

The discard rates are estimated as the proportion of the total catch (= landed catch plus discards), which means that discard proportions greater than 0.5 imply that more fish are discarded than landed. To calculate the discarded catches from a discard rate and the landed catches we use:

$$D_t = \left(\frac{C_t}{1 - P_t}\right) - C_t$$

where D_t is the discarded catches in year t, C_t is the total landed catches in year t, and P_t is the proportion of discards in year t. Because the divisor is $1 - P_t$ as P_t tends to 1.0 the divisor becomes very small and hence acts as a multiplier on total landed catch C_t. The effect of this is that when P_t is estimated to be above 0.5 the multiplying effect in the calculation of discards becomes grossly exaggerated (Figure 2).

It is recommended that once discard proportions are estimated to be above 0.5 or 0.6 then attention needs to be paid to whether or not the inclusion of discards into the CPUE and the calculation of the RBC can be considered valid. In such cases, for example Inshore Ocean Perch, the Tier 4 analysis may need to be rejected and some alternative adopted.

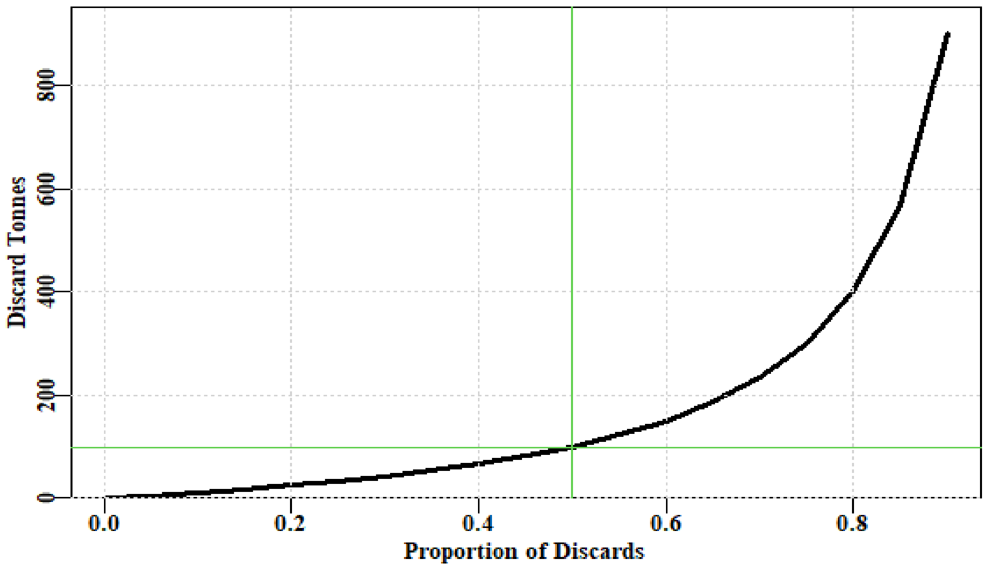

Figure 2: The influence of the proportion discarded on estimates of discarded catches. As the proportion of discards approaches 1.0 the multiplying effect in the estimation of discard amounts becomes greatly amplified.

5.3 Selection of Reference Periods

The Tier 4 requires a reference period to be selected in order to establish target and limit levels of CPUE and associated target levels of catch that are deemed by the RAG to act as a proxy for the desired state for the fishery. These act as a proxy for the Harvest Strategy Policy target and limit reference points of 48% and 20% unfished spawning biomass. The original Tier 4 rule that used a linear regression of the last four year's CPUE to determine whether catches increase or decrease was not able to rebuild a resource towards a desired target level and the current approach was developed to be able to manage a fishery towards the target and away from the limit.

The essence of the Tier 4 control rule is that it sets a RAG agreed target CPUE, which has an associated target catch. An estimate of current CPUE (usually the average of the last four years) is compared with the target and a multiplier is estimated which is to be applied to the target catch to generate the recommended biological catch.

To select a reference period requires a time series of comparable CPUE. For this reason the use of standardized CPUE should be an improvement over using, for example, the observed arithmetic or geometric mean CPUE. CPUE data is available in the SESSF for all targeted species from 1986 - 2011, although it needs to be noted that the character of the fishery has changed markedly during that period. Little et al. (2009) provide a discussion on how reference periods might be selected. They proposed a default 10-year period of 1986 – 1995, stating: "We have assumed that the average CPUE from 1986 to 1995 corresponds to that which would be attained if the stock were at the level that provides the maximum economic yield, BMEY. The limit CPUE is 40% of this CPUE." (Little et al., 2009, p 234).

For each species, reference years were selected by the RAGs to generate estimates of target catches and target CPUE. In addition, a decision was required as to whether the fishery could be considered as fully developed or otherwise during the reference period or not. Where a fishery was not considered to be fully developed the target catch rate, $CPUE_{targ}$, was divided by two as a proxy for expected changes to CPUE as the fishery develops and the resource stock size declines towards the assumed proxy target for 48% unfished biomass.

Little et al. (2009) proposed three rules used to estimate the CPUE target:

1. The CPUE target for stocks fully exploited at or prior to 1986 is based on the average CPUE from 1986-1995.
2. Where fishing exploitation up to 1986 is thought to be minimal, the CPUE determined in Step 1 is halved (to provide a CPUE proxy for B_{MEY}).
3. Where fishing exploitation after 1986 is low, the first year in which catches are above 100 t signifies the start of the 10-year period for which CPUE targeted is calculated.

As Australia's national science agency and innovation catalyst, CSIRO is solving the greatest challenges through innovative science and technology.

CSIRO. Unlocking a better future for everyone.

Contact us
1300 363 400
+61 3 9545 2176
csiroenquiries@csiro.au
www.csiro.au

For further information

CSIRO

Environment
Miriana Sporcic
+61 3 6232 2222
Miriana.sporcic@csiro.au

Dynamic T4 for SERAG

CSIRO has developed a surplus production model (SPM), which uses an approach similar to the current Tier 4 assessment method, named Dynamic Tier 4. The model specifies MSY to occur during a historical period of pre-determined reference years to set the target catch level, with this approach akin to the current Tier 4 method. Depending on data availability, the Dynamic Tier 4 assessment method can estimate all parameters of the production function (intrinsic rate of population increase parameter (*r*), total mortality corresponding to B_{MSY}/B_0 (*z*), and the maximum population size parameter (*K*)), or fewer, and can accommodate multiple CPUE series over varying time periods, which is not possible with the current Tier 4 method.

At SERAG1 2023, it was noted in the preliminary Dynamic Tier 4 assessments that stock status and biomass were declining at the start of the series when catches were low and the RAG questioned why this was occurring. This happens because the reference years are used to set the target catch, and therefore, the MSY level during this period. The model then estimates below average recruitment deviations to reduce biomass, and therefore stock status, to reach the MSY level during the reference years.

This is demonstrated in Fig. 1 for Deepwater Shark East, when the catch history from the database is used (as opposed to a reconstructed catch history, which was agreed as the series for the assessment). This model predicts a decline in stock status from the start of the series to 1995, and during this time catches are low. This decline occurs because the model is set up so that biomass is at the MSY level during the reference years (Fig 1., shaded area on middle panel). In the Deepwater Shark East example, the early years of catch are insufficient to reduce the biomass to the MSY level. Consequently, to achieve the necessary decline in biomass the model estimates below average recruitment deviations in the early years of the assessment (Fig 1. bottom panel).

Although the model relies on the pre-specified reference years, and errors in the choice of these years will impact the ability of the method to reach the target reference point, the Dynamic Tier 4 method still demonstrated improved performance compared to the current Tier 4 during management strategy evaluation (MSE) testing (see attached MSE summary document). Performance measures from the MSE demonstrated that the Dynamic Tier 4 method had (i) a reduced probability of the stock falling below the limit reference point compared to the current Tier 4, (ii) a reduced probability of a 0 t RBC and (iii) a reduced interannual variability in catches (Fig 5. in attached MSE summary document).

The Deepwater Shark West Tier 4 assessment uses an alternative target assumption because the stock is assumed to be in an unfished state during the reference years, rather than the more common assumption that the model is at the MSY level during the reference years. Currently, the Dynamic Tier 4 method does not accommodate this alternative assumption, therefore, we suggest that this year's assessment should be completed with the current Tier 4. This will provide CSIRO sufficient time to develop a solution to accommodate the alternative assumption within the Dynamic Tier 4 framework that could be implemented in future assessments.

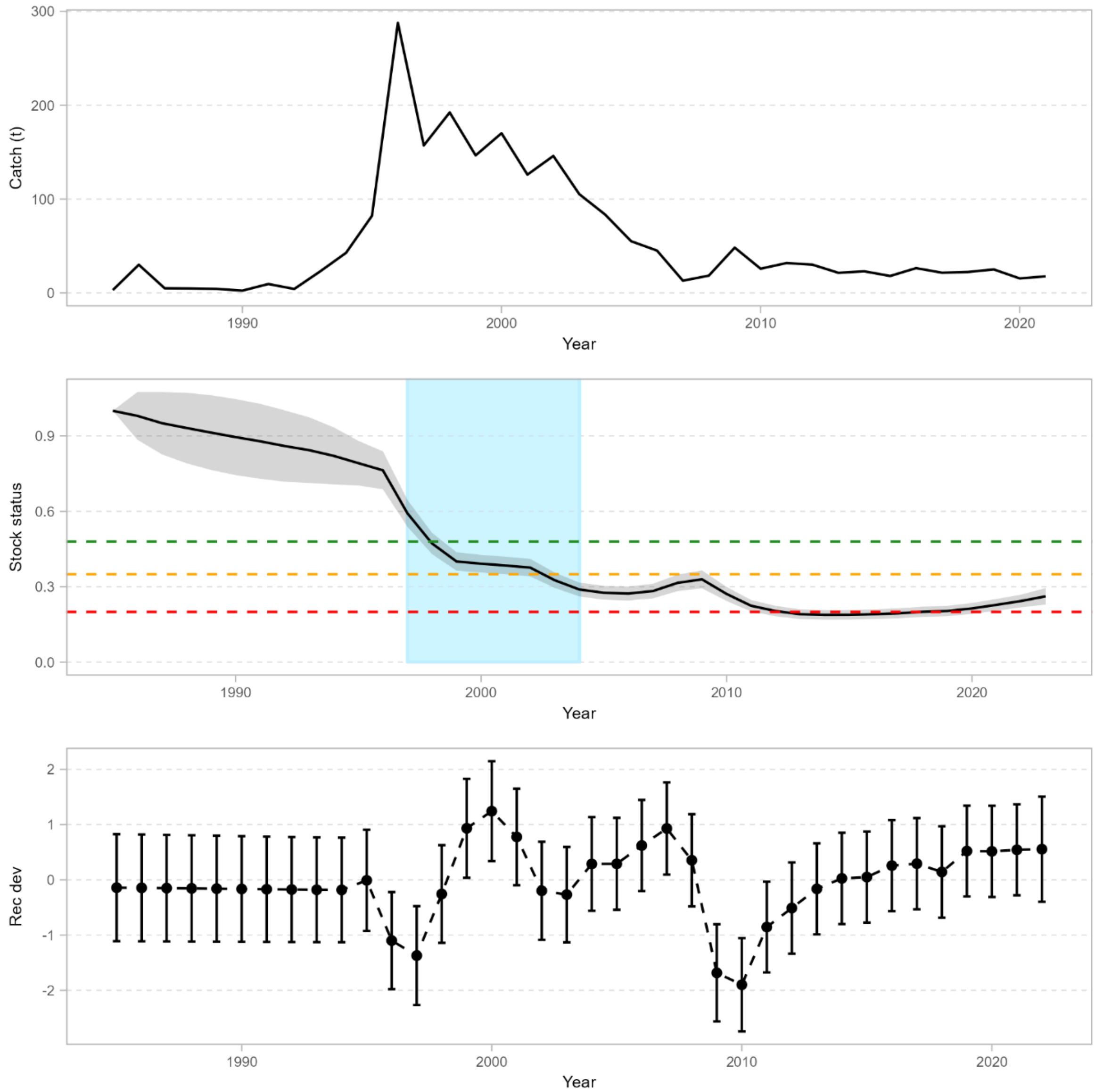

Fig 1. Catch time series (top panel), stock status (middle panel) and recruitment deviations (bottom panel) for the Deepwater Shark East preliminary Dynamic Tier 4 assessment with no reconstructed catch history. For the stock status panel, shown are the median stock status (line) with 90% intervals (shaded area), the pre-specified reference years are shaded in light blue, the green dashed line is the target reference point, orange dashed line is the breakpoint of the HCR and red dashed line is the limit reference point.