Australia's National Science Agency

Draft Tier 4 assessments for selected SESSF species (data to 2022)

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1 Executive Summary

Two Tier 4 assessments were performed for the following species and/or fisheries:

- Mirror Dory - east (*Zenopsis nebulosa*)
- Mirror Dory - west (*Zenopsis nebulosa*)

Mirror Dory – east: The 2023 estimated RBC was 269.89 t, an increase of 132.12 t compared to the 2022 estimated RBC (137.77 t). Note that the 2023 RBC is greater than the reported catch of approximately 46.8 t (113.15 t including discards) in 2022 for this stock. The increase in RBC of approximately 132 t can be mostly attributed to an increase in the most recent CPUE (including discards) and hence the mean of the most recent four-year average which is used to calculate the RBC. Also, the CPUE in 2022 is above the CPUE limit based on the Tier 4 Harvest Control Rule (0.49) and above the target CPUE, the first time since 2011.

Mirror Dory – west: The 2023 estimated RBC was 76.32 t, an increase of 27.6 t compared to the 2022 estimated RBC (48.72 t). The increase in RBC of approximately 27.6 t can be attributed to an increase in the mean of the most recent four-year average CPUE which is used to calculate the RBC. The 2023 RBC is greater than the reported catch of approximately 41 t in 2022 for this stock.

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 catch rates and exploitable biomass; if there is hyper-stability (catch rates remain stable while stock size changes) or hyper-depletion (catch rates 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 catch rates 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 catch rates with the target period may be compromised. Such changes would obviously reduce the responsiveness of the Tier 4 method to change and may generate completely inappropriate management advice. Included in this clause are the effects of targeting or not targeting of deep water or aggregated species. When catch rates are 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 a good estimate of the stock when at a depletion level of 48 % unfished spawning biomass; the Tier 4 method is based on catch rates 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 $B_{48\%}$.

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 fish killed remains.*

2.2.5 Some Implications of the Assumptions

The outcomes of the Tier 4 analysis should not be regarded with the same confidence as those from Tier 1 assessments. Even though they are termed stock assessments, in actuality they are empirical considerations 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 analysis 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 Mirror Dory East Discard

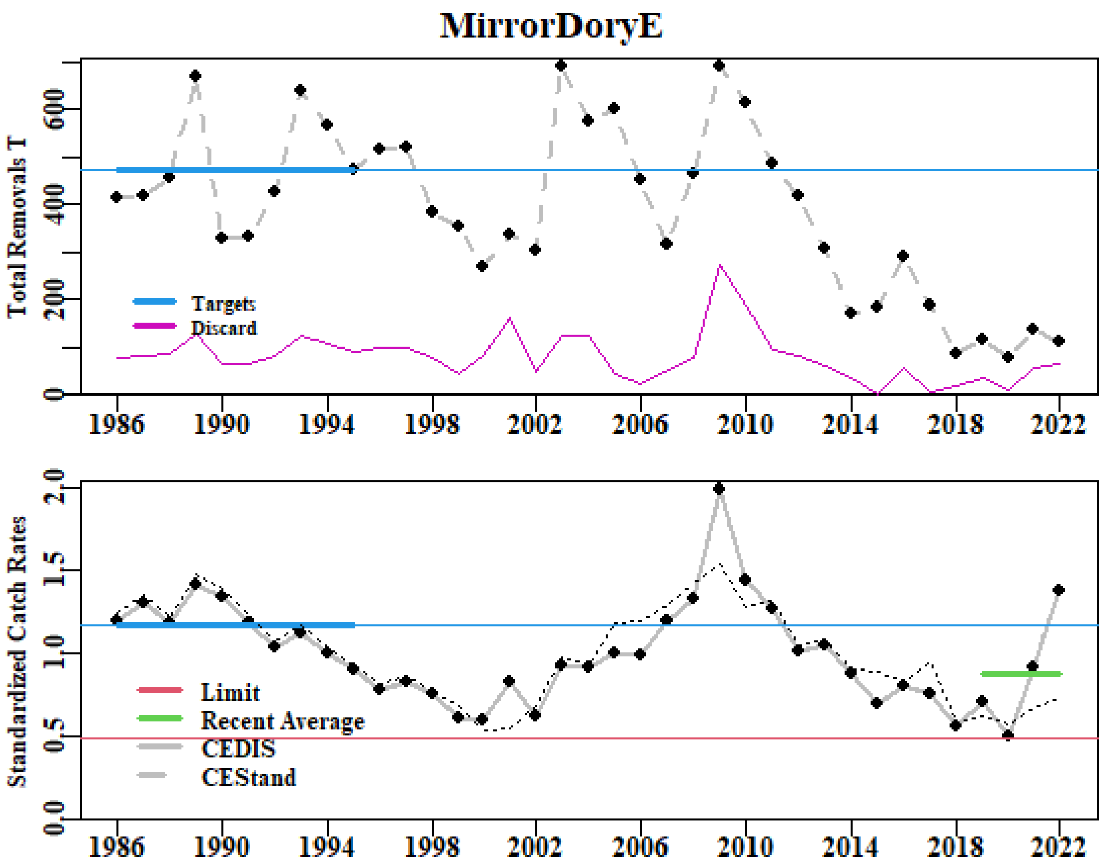

Figure 1: Mirror Dory 10 - 30 Discard. Top plot is the total removals with the fine line illustrating the target catch. Bottom plot represents the standardized CPUE with the upper fine line representing the target CPUE and the lower line the limit CPUE. Thickened lines represents the reference period for catches, CPUE, and the recent average CPUE. The thin black dotted line is the unmodified standardized CPUE before the inclusion of discards.

Table 1: Mirror Dory 10 - 30 Discard RBC calculations. C_{targ} and $CPUE_{targ}$ (CE_Target) are the targets identified in the figure above, $CPUE_{Lim}$ 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 (CE_Recent). Recommended biological catch (RBC; t). The RBC calculation does not account for predicted discards of predicted State catches. Wt_Discard is the weighted average discards from the last four years. E: east; W: west. Total Allowable Catch (TAC).

Parameter	Value	Parameter	Value
Reference_Years	1986 - 1995	Scaling	0.5706
CE_Target	1.1686	Previous (E+W) TAC (t)	129
CE_Limit	0.4869	C_{targ}	472.975
CE_Recent	0.8759	RBC (t)	269.893
Wt_Discard	54.399		

Table 2: Mirror Dory 10 - 30 Discard data for the Tier 4 calculations. Total (t) is the sum of Discards, State, Non Trawl and SEF2 catches. All values in Tonnes. CE is the standardized CPUE (Sporcic, 2023). GeoMean is the geometric mean CPUE. Discards are estimates from 1986 to present (see also details in Sporcic and Day 2021; Burch et al. 2023). Total Allowable Catch (TAC; t) are combined east and west.

Year	Catch	Discards	Total	(D/C)+1	CE	DiscCE	TAC	State
1986	334.6	79.367	413.927	1.237	1.2397	1.1963		276.903
1987	338.6	80.315	418.872	1.237	1.3530	1.3057		272.612
1988	368.9	87.510	456.396	1.237	1.2235	1.1807		297.038
1989	539.5	127.987	667.498	1.237	1.4704	1.4189		398.256
1990	266.0	63.104	329.109	1.237	1.3968	1.3479		211.547
1991	269.9	64.032	333.951	1.237	1.2281	1.1851		170.055
1992	345.4	81.946	427.378	1.237	1.0726	1.0351		153.925
1993	516.7	122.578	639.286	1.237	1.1663	1.1255	800	223.733
1994	459.2	108.931	568.113	1.237	1.0317	0.9956	800	175.184
1995	384.1	91.120	475.225	1.237	0.9279	0.8954	800	158.953
1996	417.5	99.049	516.575	1.237	0.8120	0.7836	800	166.212
1997	421.4	99.960	521.327	1.237	0.8641	0.8339	800	68.904
1998	303.2	79.336	382.526	1.262	0.7708	0.7585	800	26.987
1999	310.4	42.245	352.629	1.136	0.6815	0.6039	800	36.886
2000	189.5	81.075	270.612	1.428	0.5396	0.6009	800	11.044
2001	172.7	164.426	337.146	1.952	0.5427	0.8263	800	10.347
2002	257.2	45.702	302.865	1.178	0.6786	0.6234	640	21.648
2003	563.2	124.877	688.027	1.222	0.9692	0.9236	576	68.408
2004	451.9	122.593	574.476	1.271	0.9215	0.9137	576	106.362
2005	557.4	44.281	601.650	1.079	1.1846	0.9974	700	73.403
2006	426.6	23.351	449.927	1.055	1.1934	0.9818	634	85.430
2007	264.5	50.836	315.360	1.192	1.2874	1.1971	788	28.716
2008	390.3	75.461	465.806	1.193	1.4327	1.3335	634	22.089
2009	416.2	273.903	690.105	1.658	1.5343	1.9843	718	34.930
2010	428.7	186.822	615.559	1.436	1.2868	1.4410	718	12.019
2011	391.4	92.850	484.248	1.237	1.3141	1.2681	718	6.091
2012	337.6	80.084	417.669	1.237	1.0454	1.0088	718	5.630
2013	247.1	58.607	305.658	1.237	1.0837	1.0458	1077	3.650
2014	139.0	32.974	171.970	1.237	0.9028	0.8712	808	1.787
2015	184.7	1.115	185.793	1.006	0.8850	0.6944	437	0.595
2016	234.5	55.640	290.185	1.237	0.8277	0.7987	325	5.715
2017	183.8	4.822	188.605	1.026	0.9464	0.7575	235	0.322
2018	69.9	16.571	86.421	1.237	0.5832	0.5628	253	0.056
2019	80.2	36.078	116.286	1.450	0.6262	0.7081	188	0.006
2020	70.4	8.839	79.288	1.125	0.5725	0.5026	137	0.003
2021	78.0	57.836	135.820	1.742	0.6722	0.9131	144	0.000
2022	46.8	66.361	113.154	2.418	0.7316	1.3799	129	0.023

3.1 Discussion

The most recent standardized CPUE has increased relative to the previous year and exceeded the long-term average, the first time since 2013. The 2023 estimated RBC was 269.89 t (Table 1), an increase of 132.12 t compared to the 2022 estimated RBC (137.77 t; Sporcic 2022). Note that the 2023 RBC is greater than the reported catch of approximately 46.8 t (113.15 t including discards) in 2022 for this stock (Table 2). The increase in RBC of approximately 132 t can be mostly attributed to an increase in the most recent CPUE (including discards) and hence the mean of the most recent four-year average which is used to calculate the

RBC. Also, the CPUE in 2022 is above the CPUE limit based on the Tier 4 Harvest Control Rule (0.49) and above the CPUE target, the first time since 2011.

4 Mirror Dory West

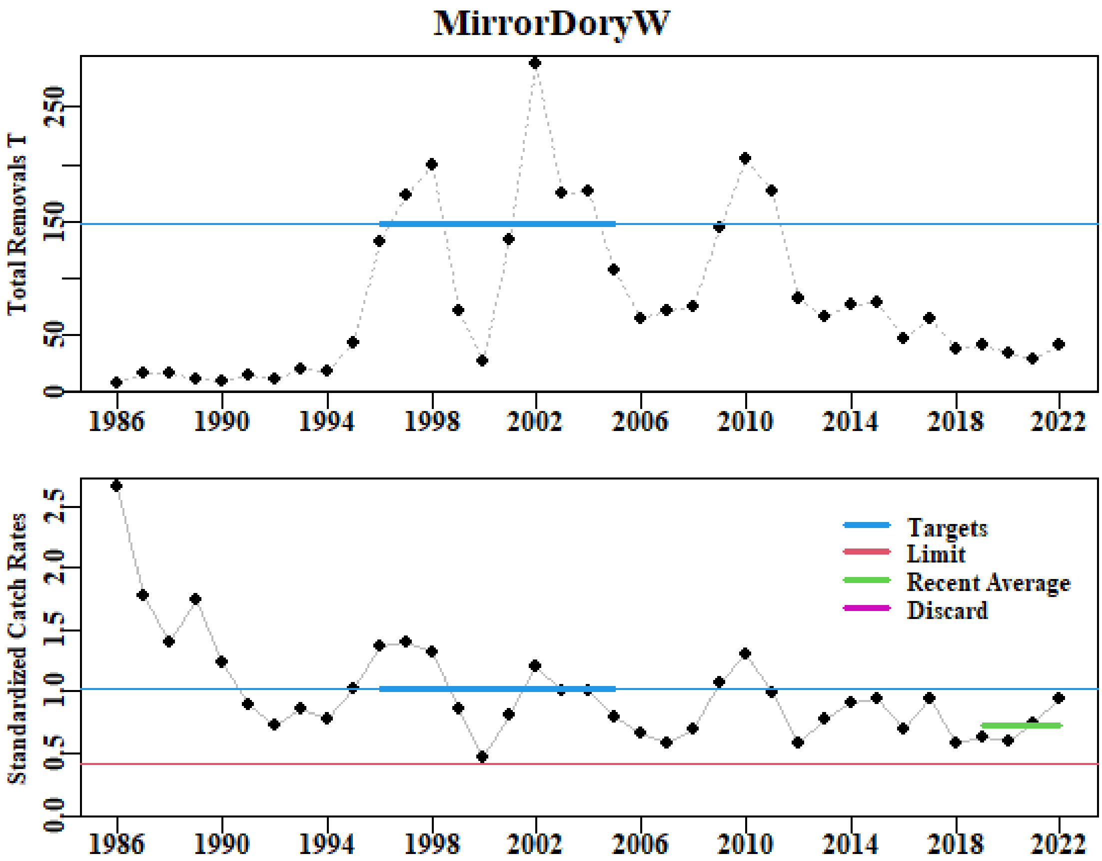

Figure 2: Mirror Dory 40 - 50. Top plot is the total removals with the fine line illustrating the target catch. Bottom plot represents the standardized CPUE with the upper fine line representing the target CPUE and the lower line the limit CPUE. Thickened lines represents the reference period for catches, CPUE, and the recent average CPUE.

Table 3: Mirror Dory 40 - 50 RBC calculations. C_{targ} and $CPUE_{targ}$ (CE_Target) are the targets identified in the figure above, $CPUE_{Lim}$ 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 (CE_Recent). Recommended biological catch (RBC; t). The RBC calculation does not account for predicted discards of predicted State catches. Wt_Discard is the weighted average discards from the last four years. E: east; W: west. Total Allowable Catch (TAC).

Parameter	Value	Parameter	Value
Reference_Years	1996 - 2005	Scaling	0.5152
CE_Target	1.0219	Previous TAC (E+W) (t)	129
CE_Limit	0.4258	C_{targ}	148.125
CE_Recent	0.733	RBC (t)	76.318
Wt_Discard			

Table 4: Mirror Dory 40 - 50 data for the Tier 4 calculations. Total (t) is the sum of Discards, State, Non Trawl and SEF2 catches. All values in Tonnes. CE is the standardized CPUE (Sporcic, 2023). GeoMean is the geometric mean CPUE. Discards are estimates from 1986 to present (see also details in Sporcic and Day 2021; Burch et al. 2022). Total Allowable Catch (TAC; t) are combined east and west.

Year	Catch	Discards	Total	State	CE	GeoMean	TAC
1986	8		7.800		2.6503	1.8502	
1987	16		16.123		1.7785	1.7955	
1988	17		17.104		1.4042	1.8502	
1989	11		11.227		1.7364	2.2531	
1990	10		10.151		1.2292	1.8851	
1991	15		14.928		0.8964	0.8853	
1992	11		10.746	0.480	0.7255	0.7262	
1993	19		19.330	0.720	0.8560	0.8306	800
1994	19		18.646	0.334	0.7820	0.7361	800
1995	43		42.519	0.738	1.0266	0.7660	800
1996	131		131.018	0.238	1.3706	1.1639	800
1997	172		171.829	0.138	1.3931	1.2186	800
1998	200		199.769	0.001	1.3153	1.3678	800
1999	72		71.677	0.006	0.8548	0.8455	800
2000	28		27.792	0.001	0.4698	0.3929	800
2001	134		133.762		0.8139	0.7013	800
2002	288		287.994	0.002	1.2068	1.2335	640
2003	175		174.927	0.060	1.0038	1.0296	576
2004	176		175.911	0.024	1.0002	1.0097	576
2005	107		106.569	0.039	0.7911	0.7560	700
2006	65		64.651	0.005	0.6581	0.7809	634
2007	71		71.390	0.005	0.5897	0.7113	788
2008	74		74.123	0.014	0.6990	0.8008	634
2009	145		144.958		1.0659	0.9948	718
2010	204		204.199		1.3010	1.3181	718
2011	177		177.025	0.001	0.9948	1.0843	718
2012	82		81.727		0.5858	0.8406	718
2013	65		65.246	0.001	0.7859	1.0345	1077
2014	78		77.544		0.9068	0.9749	808
2015	78		77.931		0.9464	0.8654	437
2016	47		47.210		0.6970	0.8207	325
2017	65		64.540		0.9441	0.8207	235
2018	37		37.385		0.5892	0.5372	253
2019	41		41.456		0.6324	0.5919	188
2020	34		33.929		0.6016	0.4725	137
2021	29		28.806		0.7475	0.5372	144
2022	41		41.144		0.9503	0.5173	129

4.1 Discussion

With the fishery only beginning to report significant catches from about 1996 onwards the reference period used is relatively recent. Nevertheless, there are now 13 years between the reference period and the start of the most recent four years used to denote the current state of the fishery.

The 2023 estimated RBC was 76.32 t (Table 3), an increase of 27.6 t compared to the 2022 estimated RBC (48.72 t; Sporcic 2022). The increase in RBC of approximately 27.6 t can be attributed to an increase in the mean of the most recent four-year average CPUE which is used to calculate the RBC. The 2023 RBC is greater than the reported catch of approximately 41 t in 2022 for this stock (Table 4).

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6 Appendix: Methods

6.1 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 catch rates 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 2010 data relating to catches and discards, from both State waters and SEF2 data sets, were provided by AFMA, with initial processing by N. Klaer and J. Upston of CSIRO. All catch rate 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 (2019), 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 essentially uses a ratio of current catch rates 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.

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

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

If new data becomes available, for example, more State data has become available this year, or other large changes occur in the catch rates 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. $CPUE_{\text{targ}}$ is the target CPUE for the species,
3. $CPUE_{\text{lim}}$ is the limit CPUE for the species = 0.4 * $CPUE_{\text{targ}}$,
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.

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

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 catch rates. 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 catch rates 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.

6.2 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 catch rates 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 are 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.

Catch rates are used in assessments as an index of relative abundance through time and it is the trends exhibited by the catch rates 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 catch rates 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 catch rates 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 catch rates should be examined each year as a sensitivity analysis to contrast with the outcome from the un-augmented catch rates (Haddon, 2010).

6.2.1 Analyses Including Discards

Discard rates cannot simply be added to known catches on the way to calculating catch rates. The standardized catch rates are 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 catch rates would be identical to the first equation dealing with $\sum D_t$. In practice, the catch rates used with the multiplier are the standardized catch rates (e.g. Haddon, 2014).

6.2.2 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 8).

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.

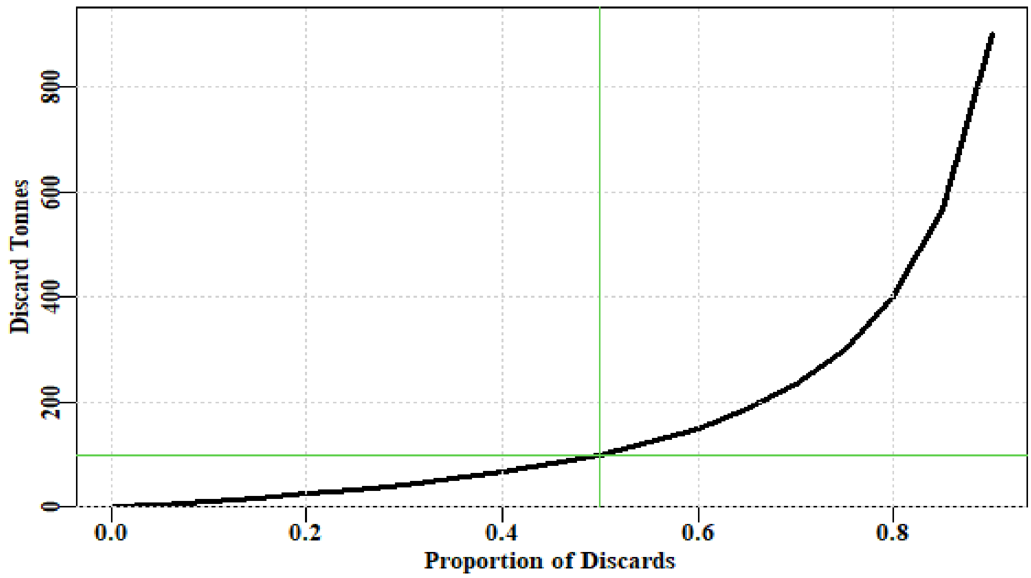

Figure 5: The influence of the proportion discarded on estimates of discarded catches. As the proportion of discards approaches 1.0 the multiplying effect in the estimation of discard amounts becomes greatly amplified.

6.3 Selection of Reference Periods

The Tier 4 requires a reference period to be selected in order to establish target and limit levels of catch rates 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 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 so as to be able to manage a fishery towards a target and away from a 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, B_{MEY}. 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 catch rates. 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 catch rates 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.

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