Stock Status Summary 2021

NSW Stock Status Summary – Grey Morwong
(*Nemadactylus douglasii*)

Assessment Authors and Year

Stewart, J. 2020. NSW Stock Status Summary 2018/19 – Grey Morwong – (*Nemadactylus douglasii).* NSW Department of Primary Industries. Fisheries NSW. 13 pp.

Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Grey Morwong is currently assessed as **Depleted** for the NSW component of the stock.

Stock Structure

The stock structure of Grey Morwong has not been formally examined through genetics; however based on their reasonably limited distribution along south-eastern Australia, the complex but southerly flowing Eastern Australian Current and an extended pelagic larval phase, it is likely to constitute a single stock. Based on this evidence, the stock status of Grey Morwong is reported at a biological stock level.

The data presented in this summary relate to the NSW part of the stock.

Stock Status

Catch Trends - Commercial fisheries

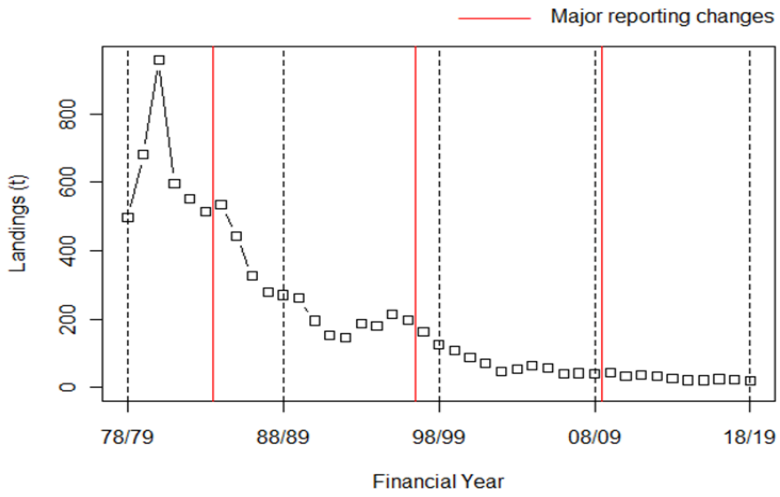


Figure 1. Commercial landings (including available historical records) of Grey morwong for NSW from 1978/79 to 2018/19 for all fishing methods.

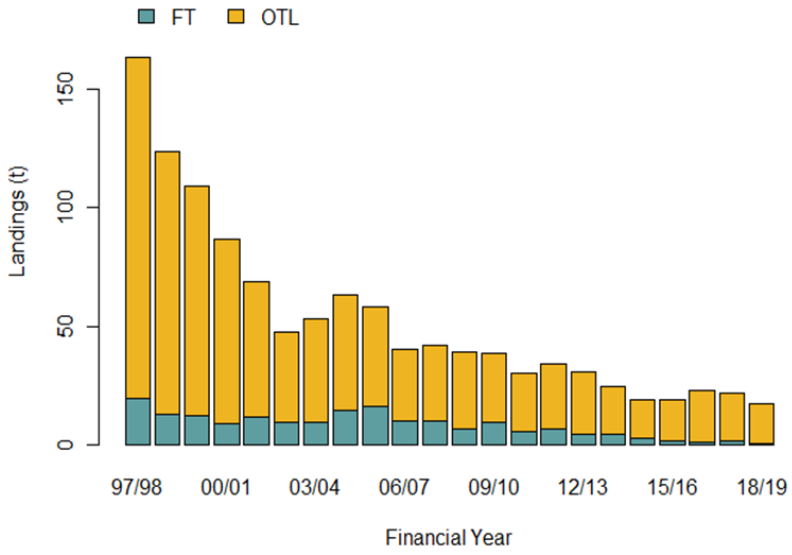


Figure 2. Landings by Fishery (including available historical records) of Grey Morwong in NSW for years 1997/98 to 2018/19. FT = Fish Trawl; OTL = Ocean Trap and Line

Recreational and Indigenous

The most recent estimate of the recreational harvest of Grey Morwong in NSW was approximately 27,000 fish at around 21.8 t (Murphy et al., 2020). This estimate is somewhat lower than the estimated 30,000 fish harvested during 2013/14 (West et al., 2015) with an estimated weight of approximately 29 t (NSWDPI unpublished). This estimate is again substantially lower than the previous estimate during 2000/01 of approximately 130,000 fish (Henry and Lyle, 2003) with an estimated weight of approximately 156 t (NSWDPI unpublished).

There are no data on aboriginal harvest.

Fishing effort trends

Commercial fishing effort on Grey Morwong is difficult to estimate prior to 2009/10 as the monthly catch returns listed days fished per month by method and had no direct link to the number of days within a month that a particular species was landed. The number of days fish trapping reported for when Grey Morwong were also reported in a month have declined from nearly 13,000 during 1997/98 to fewer than 3,000 during since 2014/15 (Fig. 3). More accurate estimates of fishing effort are available after 2009/10 and show that the number of days using fish trapping on which Grey Morwong were landed have declined from approximately 2,300 in 1997/98 to less than 1,700 in 2018/19, and that the number of days using fish trawling on which Grey Morwong were landed have declined from approximately 400 in 1997/98 to only 59 in 2018/19 (Fig. 4).

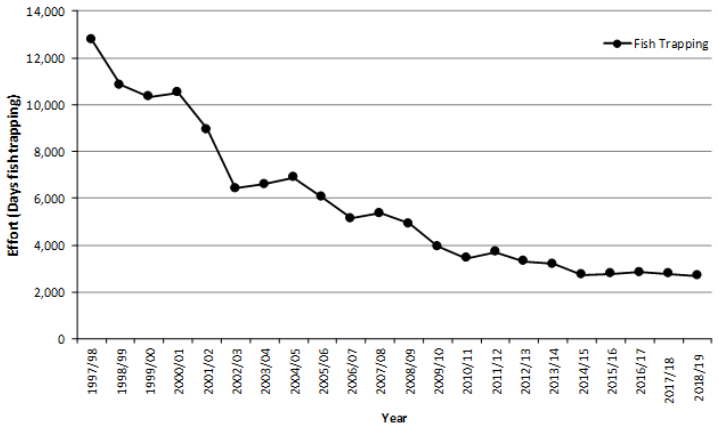


Figure 3. Annual reported days fished for months when Grey Morwong were landed by fish trapping 1997/98 to 2018/19.

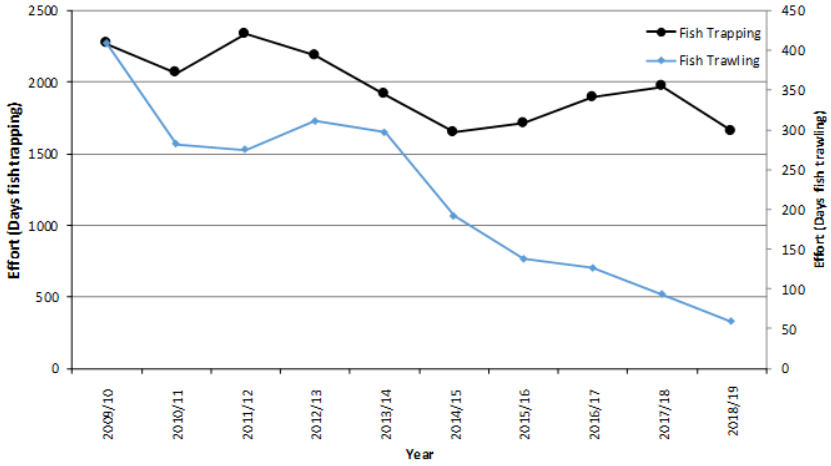


Figure 4. Annual reported days fished when Grey Morwong were landed by fish trapping and fish trawling 2009/10 to 2018/19.

Catch rate trends

Catch rates of Grey Morwong using the method of fish trapping were standardized for the periods 1997/98 to 2008/09 and 2009/10 to 2018/19 separately as a result of changes in logbook reporting from monthly to daily records in 1997/98. Catch rates were standardized for month, authorized fisher and latitude of landings. Standardization was done using the r-package 'cede', with outputs standardized to 1, and the 2 time series matched by standardizing the catch rates during 2008/09 and 2009/10 (the years before and after the logbook change) to be equal.

Standardized catch rates of Grey Morwong using the method of fish trapping declined steadily since 1997/98 with a slight increase in 2016/17 and 2017/18, and in 2018/19 were approximately 32% of the 1997/98 level (Fig. 5).

Stock Assessment Methodology

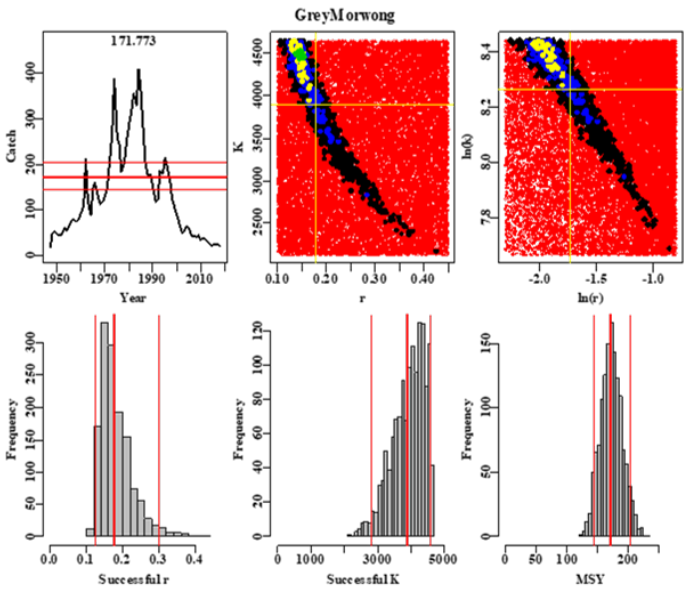
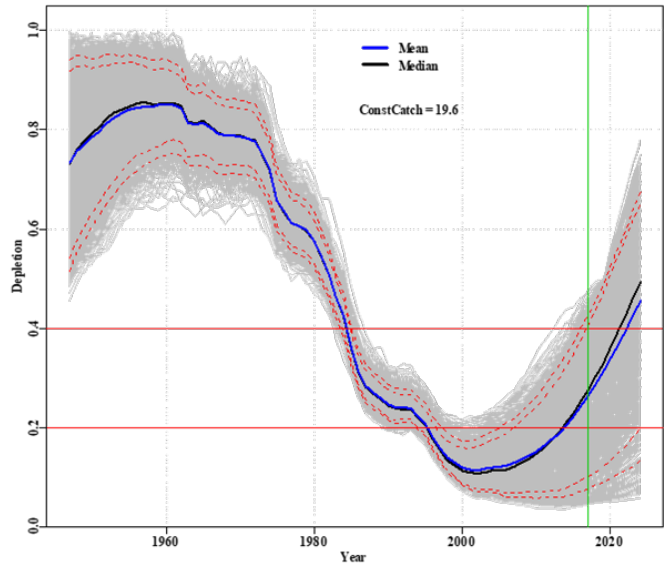
<table>
<tr><td>Year of Most Recent Assessment</td><td>2020</td></tr>
<tr><td>Assessment method</td><td>Weight of Evidence
1. Catch-MSY model-assisted catch-only assessment (Martell and Froese, 2013) using the 'simpleSA' package in R (Haddon et al. 2018).
This uses population productivity (r) and carrying capacity (K) parameters of an underlying Schaefer production model, applied to total annual catches, to estimate the ranges in biomass and harvest rate that could have resulted in the annual catches.
2. Age-structured Production Model.
3. Catch rates.
4. Size composition in landed commercial catch 1970s to 2018/19.
5. Age composition in commercial catch 2005/06, 2011/12, 2015/16.
6. Mortality estimates.</td></tr>
<tr><td>Main data inputs</td><td>1. Annual total landed catch of Grey Morwong by the NSW commercial fishery from 1945 – 2018.
2. Annual total landed catch of Grey Morwong by the NSW commercial fishery from 1997 – 2018. Standardised CPUE 1997 to 2018.
Biological Parameters:
<table><tr><td>maxage the maximum age</td><td>22</td></tr><tr><td>M natural mortality</td><td>0.14</td></tr><tr><td>Linf vB asymptotic maximum length</td><td>35.08</td></tr><tr><td>K vB Brody growth coefficient</td><td>0.37</td></tr><tr><td>t0 theoretical age at zero length</td><td>-0.41</td></tr><tr><td>Waa weight at age a parameter</td><td>1.97E-05</td></tr><tr><td>Wab weight at age b parameter</td><td>2.99042</td></tr><tr><td>M50a age at 50% maturity</td><td>2.8</td></tr><tr><td>deltaM diff between ages at 50 and 95% maturity</td><td>2</td></tr><tr><td>ela50 age at 50% selectivity</td><td>3.1</td></tr><tr><td>deltaS diff between 50 and 95% selectivity</td><td>1</td></tr><tr><td>steep stock recruitment steepness</td><td>0.6</td></tr><tr><td>Ln(R0) initial value but this will be estimated</td><td>14</td></tr></table>3. Catch rates fish trapping 1997 to 2018
4. Size composition in landed commercial catch 1970s to 2018/19
5. Age composition in commercial catch 2005/06, 2011/12, 2015/16.</td></tr>
</table>

	6. Mortality estimates derived from catch curves and empirical equations based on maximum age which was inferred to be 40 years based on the longevity of other Morwongs (Then et al., 2015).
Key model structure and Assumptions	1. 'Resilience' was set to Low in the Catch MSY model specification, which allows for a possible range in population growth rate (r) of 0.1 - 0.6. 2. The age-structured production model is a surplus production model based upon an age-structured model of production. A 3 parameter model was chosen as the stock is assumed to have ben fished down considerably by 1997. Initial parameters for the average unfished recruitment level, the standard deviation of the errors around the CPUE data and an initial depletion estimate for 1997 were set as 19, 0.15, and 0.2. 3. Standardized catch rates - General Linear Models (which with log-normal errors give the same results as simple linear models). 4. Trends in size composition in the landed commercial catch 1970s to 2018/19 – assuming these are representative of the fishable stock. 5. Pattern of age composition in commercial catch 2005/06, 2011/12, 2015/16 – assuming this is representative of the fishable stock. 6. Mortality estimates – assuming the catch curves were based on a sample representative of the fishable stock and that the empirical estimates of natural mortality are accurate.
Sources of Uncertainty evaluated	The Catch-MSY analysis explored wide ranges of underlying Schaefer production model r and K, achieving successful biomass and harvest rate trajectories over 95% ranges of: r = 0.11 - 0.30; and K = 2990 t - 4607 t. The assessment successfully covered modes in the probability distributions of r, K and MSY. The production model incorporated variance around the CPUE data and outputs included variances around parameters. Uncertainty around catch rates was assessed through standardizing and comparing data pre and post 1997 when logbooks changed.

Status Indicators and Limits Reference Levels

Biomass indicator or proxy	1. Mean annual biomass and depletion level, as estimated in these assessments. 2. Standardized catch rates.
Biomass Limit Reference Level	B_{lim}, expressed as 0.2 of K (B_0), the carrying capacity for the stock as estimated in this assessment. No formal reference level for catch rates; however, trends are assessed.
Fishing mortality indicator or proxy	Mean annual harvest rate, as estimated in this assessment. Landed catch Fishing effort Size composition in landed catch Age composition Mortality
Fishing mortality Limit Reference Level	F_{targ}, being the estimated harvest rate that should prevent the stock from declining below the biomass target B_{targ} (BMSY). Landed catch: No formal reference levels determined. Trends in indicator through time are used to estimate trends in fishing mortality. Fishing effort: No formal reference levels determined. Trends in indicator through time are used to estimate trends in fishing mortality. Size composition in landed catch: No formal reference levels determined. Trends in indicator through time are used to estimate trends in fishing mortality. Age composition: No formal reference levels determined. Qualitative assessment of age truncation Mortality: Ratio of F:M. F not to exceed M.

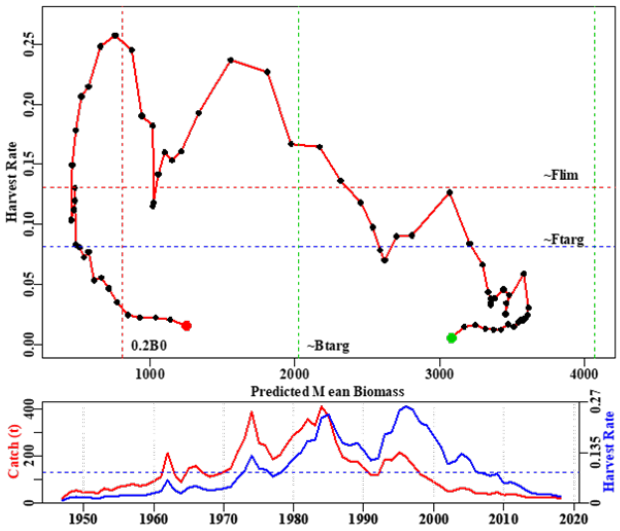
Stock Assessment Results

1.Grey Morwong C_{MSY} assessment results showing: annual catch trajectory (t) with estimated MSY and 90th percentile; scatter plots of *K* vs *r* combinations explored with red dots depicting failure and other colours depicting combinations of initial depletion that succeeded for each *r-K* pair (right-hand plot is the log-transformed version of the left-hand plot); and histograms of the probability distributions of successful *r-K* pairs and the resulting MSY estimates, with red lines showing the median and 90th percentile confidence intervals.	
1. Range of depletion trajectories for successful *r-K* pairs, showing mean and median annual depletion and 80th and 90th percentiles (dashed lines). The lower red line is the $0.2B_0$ limit reference point, while the upper is the Schaefer B_{MSY} ($0.5B_0$) target reference point. The vertical green line indicates 2018, the final year for which data are available. Projected depletion levels are shown for 5 years thereafter at constant catch at the 2018 level of 19.6 t.	

1 Grey Morwong stock status trajectory from 1945 - 2018, showing annual stock status in estimated biomass (t) and harvest rate.

Reference levels are shown for biomass target (B_{MSY}) and limit ($0.2B_0$) reference levels, and for the corresponding harvest rates that should keep biomass at or above the target F_{targ} (F_{MSY}) and above the limit F_{lim} (F_{B20})

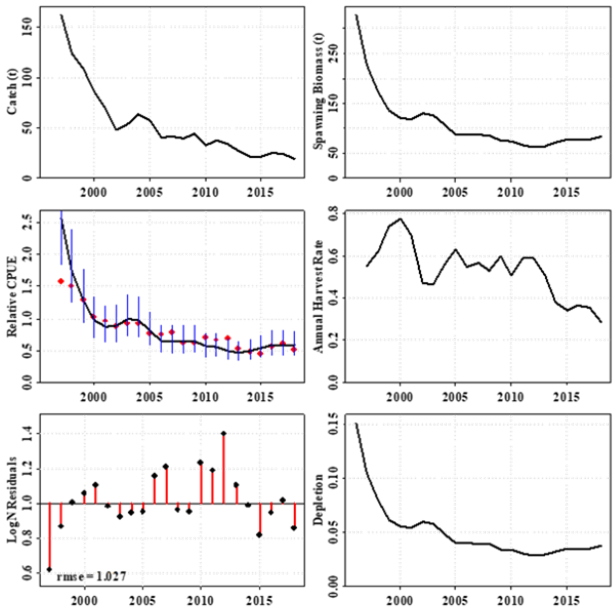
The start of the trajectory in 1945 is indicated by a green point and final year 2018 by a red point. The red line on the bottom plot is catch and the blue line is harvest rate.

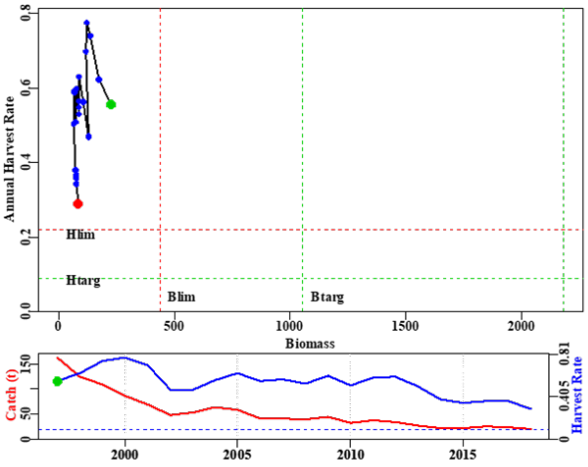
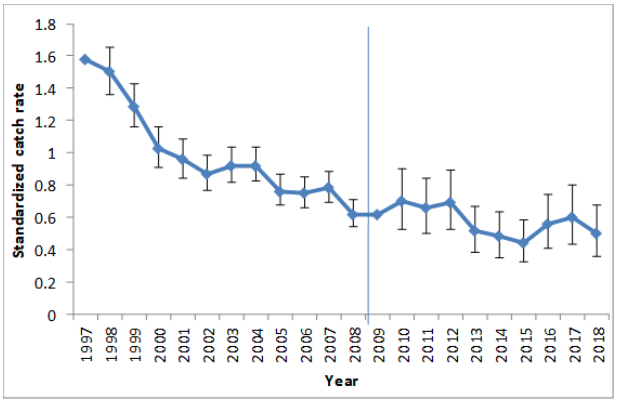


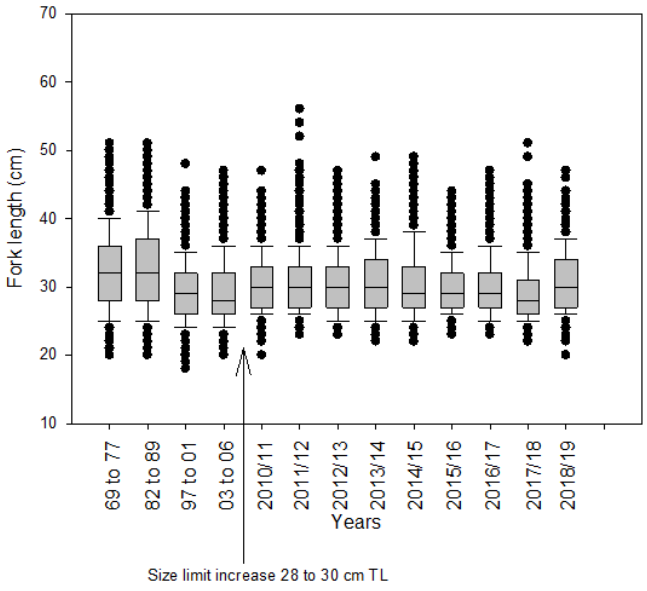
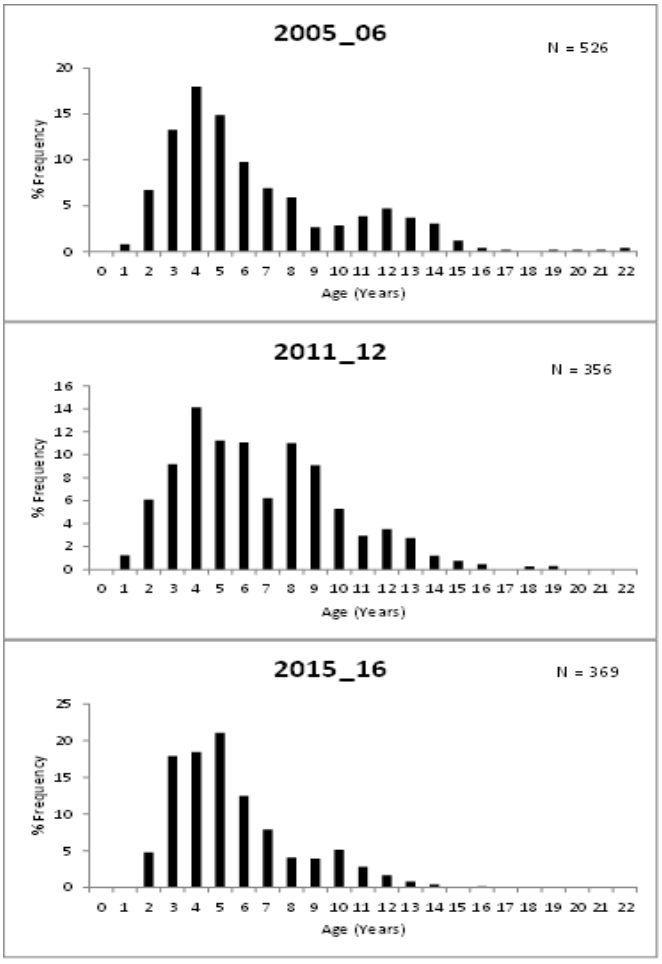
1. Summary output of key parameters from the Grey Morwong Catch-MSY stock assessment, showing mean (50%) estimates for r, K, MSY and Current Depletion, with 95% intervals

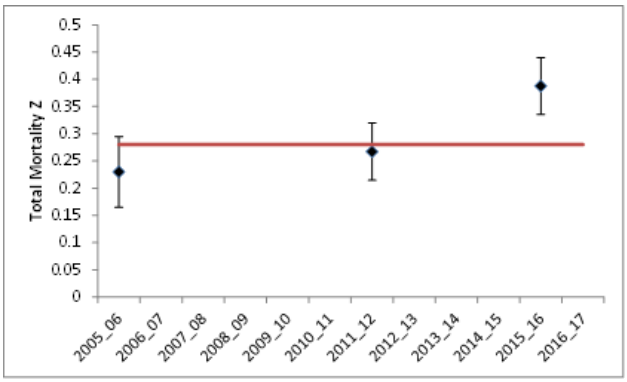
Parameter	2.50%	50.00%	97.50%
r	0.11	0.17	0.30
K	2990.37	4007.72	4607.41
MSY	139.97	172.26	208.90
CurrDepl	0.06	0.33	0.49

2. Grey Morwong age-structured production model assessment results showing catch, standardized CPUE with model fit, spawning biomass, annual harvest rate and relative depletion levels.



2. Grey Morwong stock status trajectory from 1997 - 2018, showing annual stock status in estimated biomass (t) and harvest rate. Reference levels are shown for biomass target (B_{MSY}) and limit ($0.2B_0$) reference levels, and for the corresponding harvest rates that should keep biomass at or above the target F_{targ} (F_{MSY}) and above the limit F_{lim} (F_{B20}) The start of the trajectory in 1997 is indicated by a green point and final year 2018 by a red point. The red line on the bottom plot is catch and the blue line is harvest rate.	
3. Catch rates fish trapping 1997 to 2018.	 Figure 5. Standardized commercial catch rates of Grey Morwong using fish trapping for years 1997/98 to 2018/19 in NSW. Note that the catch rates were standardized to be equal for 2008 and 2009 to account for changes in logbook reporting at that time.

4. Size composition in landed commercial catch 1970s to 2018/19.	
5. Age composition in commercial catch 2005/06, 2011/12, 2015/16.	

6. Mortality estimates derived from catch curves fitted between the ages of 4 and 16 years for Grey Morwong. The horizontal line represents what is considered the best estimate of Natural Mortality x 2.	
Biomass status in relation to Limit	The Catch-MSY model using data since 1945 indicated that the biomass declined rapidly from the 1970s and fell below B_{lim} of 0.2 during the mid- 1990s. The model predicted a fairly rapid increase in biomass from around 2010 to approximately 0.34 by 2018/19. This deterministic model will equate periods of low catches with increases in biomass and as such it is recommended that any depletion estimates from the catch-MSY method, especially where recent catches have been low, should be confirmed through independent evidence. The age-structured Production Model indicated that the Grey Morwong biomass may have been depleted to around 0.15 of B_0 in 1997 and may have declined further since then to below 0.05. The standardized catch rates indicate that the available biomass of Grey Morwong has declined substantially since 1997. Catch rates during 2018/19 were approximately 40% of the 1997/98 levels. The weight of evidence is that the biomass of Grey Morwong declined rapidly during the 1970s and 80s to be below 0.2 of B_0 during the mid-1990s. The biomass has continued to decline since that time and is currently well below the limit reference point.
Fishing mortality in relation to Limit	Estimated mean harvest rates exceeded F_{targ} between the 1970s, 80s and early 2000s. The landed commercial catch has declined substantially since the 1970s. The Catch-MSY model estimated that landings exceeded the commercial generated MSY substantially during the 1970s, 80s and 90s and has been beneath that level since. Commercial fishing effort has declined steadily since the late 1990s. The size composition in the landed catch indicates a substantial decline in the proportion of larger fish in landings since the 1970s and 80s.

<table>
<tr><td></td><td>The age compositions from 2005/06, 2011/12, 2015/16 indicate variable year class strengths as well as age-class truncation, with relatively few old fish present.
Estimates of mortality rates suggest that in recent years F has approximated M; however F exceeded M during the most recent year.
The weight of evidence is that Fishing mortality was excessive during the 1970s to early 2000s. Since that time fishing mortality has declined; however not to the level to allow the biomass to recover to above the limit reference point.</td></tr>
<tr><td>Previous SAFS stock status</td><td>SAFS 2018 - Depleted.
Within the NSW assessment framework, Grey Morwong were previously assessed as:
<table>
<tr><th>Year</th><th>Exploitation Status</th></tr>
<tr><td>2003/04</td><td>Undefined</td></tr>
<tr><td>2004/05</td><td>Fully Fished</td></tr>
<tr><td>2005/06</td><td>Fully Fished</td></tr>
<tr><td>2006/07</td><td>Overfished</td></tr>
<tr><td>2007/08</td><td>Overfished</td></tr>
<tr><td>2008/09</td><td>Overfished</td></tr>
<tr><td>2009/10</td><td>Overfished</td></tr>
<tr><td>2010/11</td><td>Overfished</td></tr>
<tr><td>2011/12</td><td>Overfished</td></tr>
<tr><td>2012/13</td><td>Overfished</td></tr>
<tr><td>2013/14</td><td>Overfished</td></tr>
<tr><td>2014/15</td><td>Overfished</td></tr>
</table></td></tr>
<tr><td>Current SAFS stock status</td><td>The above evidence indicates that the biomass of this stock is likely to be depleted and that recruitment is likely to be impaired.
The above evidence indicates that current fishing mortality levels are expected to prevent the stock recovering from a recruitment impaired state.
On the basis of the evidence provided above, the NSW part of the biological stock is classified as a Depleted stock.</td></tr>
</table>

Qualifying Comments

There is considerable uncertainty in the estimates of biomass depletion derived from catch data using Schaefer production model-assisted Catch-MSY analysis. However, the model estimated a substantial decline in biomass during the 1970s, 80s and 90s to below the limit reference point, followed by an increase during the 2010s as catches became very small. This response is due to the deterministic nature of the model where low catches will translate to increases in biomass. The age-structured population model from 1997 onwards and the standardized catch rates both suggest that the stock has not recovered and has in fact declined during that period. Trends from the recreational fishery, which is a substantial component of the total catch, follow a similar large decline since 2000/01, suggesting that availability has also declined for this sector.

New South Wales has historically landed the largest proportion of the total catch of Grey Morwong and is the only jurisdiction that has sufficient information to assess the status of the stock. As such it is likely that this SAFS status of Depleted could be applied to the entire biological stock.

References

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

Henry, G.W. and J.M. Lyle (2003). The National Recreational and Indigenous Fishing Survey. Final Report to the Fisheries Research & Development Corporation and the Fisheries Action Program Project FRDC 1999/158. NSW Fisheries Final Report Series No. 48. 188 pp. Cronulla, NSW Fisheries.

Murphy, J.J., Ochwada-Doyle, F.A., West, L.D., Stark, K.E. and Hughes, J.M., (2020), The NSW Recreational Fisheries Monitoring Program - survey of recreational fishing, 2017/18. NSW DPI - Fisheries Final Report Series No. 158.

Then, A.Y., Hoenig, J.M., Hall, N.G., Hewitt, D.A. and Handling editor: Ernesto Jardim, (2015). Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species. ICES Journal of Marine Science, 72(1), pp.82-92.

West, L.D., K.E. Stark, J.J. Murphy, J.M. Lyle and F.A. Doyle (2015). Survey of recreational fishing in New South Wales and the ACT, 2013/14. Fisheries Final Report Series.