Stock Status Summary – 2021

NSW Stock Status Summary - Teraglin *(Atractoscion atelodus)*

Assessment Authors and Year

Stewart, J. and Hegarty, A. M. 2020. NSW Stock Status Summary 2018/19 – Teraglin (*Atractoscion atelodus*). NSW Department of Primary Industries. Fisheries. 17 pp

Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Teraglin are currently assessed as Sustainable for the NSW component of the stock.

Stock Structure

Teraglin (*Atractoscion atelodus*) was recently distinguished as a distinct species that occurs only in eastern Australia, having formerly been known as *Atractoscion aequidens* which also occurs around southern Africa from Angola to South Africa (Song et al. 2017). Within Australia Teraglin are distributed from southern Queensland to Montague Island in NSW. Due to the limited latitudinal distribution along eastern-Australia, and influence of the prevailing southerly flowing Eastern Australian Current in distributing larvae across this area Teraglin are considered to be a single biological stock in this region – the Eastern Australia biological stock.

The data presented in this summary relate mainly to the NSW part of the stock; however Eastern Australia biological stock data from Queensland are used within the stock assessment.

Stock Status – New South Wales

Catch Trends

Commercial

Commercial landings of Teraglin in NSW show a long history of decline, overlaying a strong cyclical pattern (Fig. 1). Annual landings peaked at more than 200 t during the late 1950s and have been fluctuating around a mean of 23 t p.a. since 1997/98. More than 80% of the reported commercial catch since 2009/10 has been from the Ocean Trap & Line Fishery, predominantly (70% since 2009/10) using the method of handline, with the Trawl catch generally being around 15 to 30% of the total landings (Fig. 2).

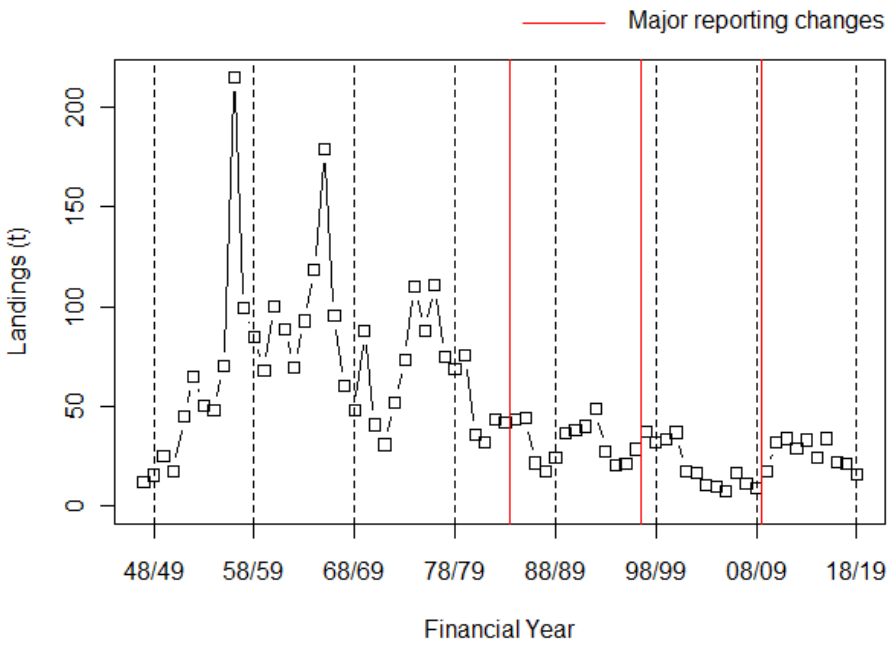


Figure 1. Commercial landings (including available historical records) of Teraglin for NSW from 1947/48 to 2018/19 for all fishing methods.

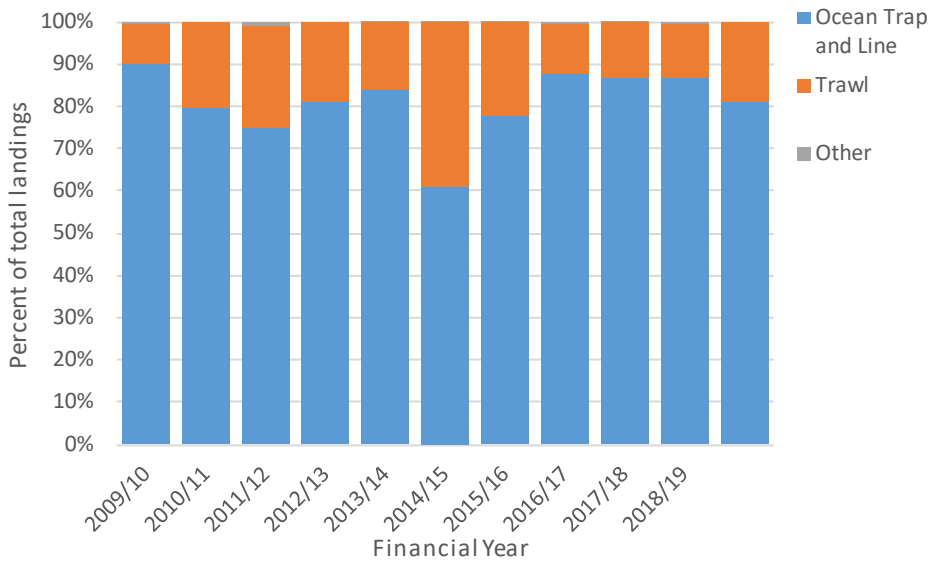


Figure 2. Landings by Fishery of Teraglin in NSW for years 2009/10 to 2019/20.

Recreational and Indigenous

The most recent estimate of the recreational harvest of Teraglin in NSW was made for 2017/18 and was approximately 11,000 fish at around 18.2 t (Murphy et al., 2020). This estimate is considered to be unreliable due to a relatively few fishers surveyed who retained Teraglin. It also

only encompasses households with a Recreational Fishing Fee licence holder and so will be an under-estimate. The previous estimate of approximately 33,000 Teraglin retained by recreational fishers during 2013/14 was around 33 t (West et al., 2015). In 2000/01 the Recreational and Indigenous Fishing Survey (Henry and Lyle, 2003) estimated approximately 71,000 fish were retained by fishers in NSW at around 73 t (NSWDPI Unpublished). While these survey results are not directly comparable due to differencing sampling frames, they likely represent a considerable decline in recreational harvest since 2000/01.

Total historical harvest from the NSW Teraglin fishery was reconstructed by estimating recreational harvest prior to, and between, survey estimates. Hindcasting the recreational harvest prior to 2000/01 was done using estimates of recreational marine fishing effort nationally as reported by Kleisner et al., 2015. That study used coastal population statistics from the Australian Bureau of Statistics with linear interpolation between census years. A recreational fishing participation rate of 19.5% was used between 1950 and 1970, after which participation was modelled to increase linearly to 34% in 1980 based on survey data (Anon. 1984) to account for an agreed increase during that time. Participation rate was constant at 34% between 1980 and 1990, after which it declined linearly to 19.5% in 2000 based on the NIRFS (Henry and Lyle, 2003) to account for perceived decline in recreational fishing effort. Recreational fishing effort relative to 2000/01 was indexed using data in Kleisner et al., 2015 and estimates of recreational harvest were made by applying the relative recreational fishing effort each year relative to 2000/01 by the estimated harvest in 2000/01 of approximately 73 t. After 2000/01, harvest was estimated to follow a linear path between each survey, with the estimate in 2018/19 being set as the same as in 2017/18.

Total harvest peaked at approximately 250 t during the 1950s and has declined steadily since the mid-1970s to be less than 50 t p.a. during the past 2 years (Fig. 3). The harvest has been predominantly from the recreational fishing sector.

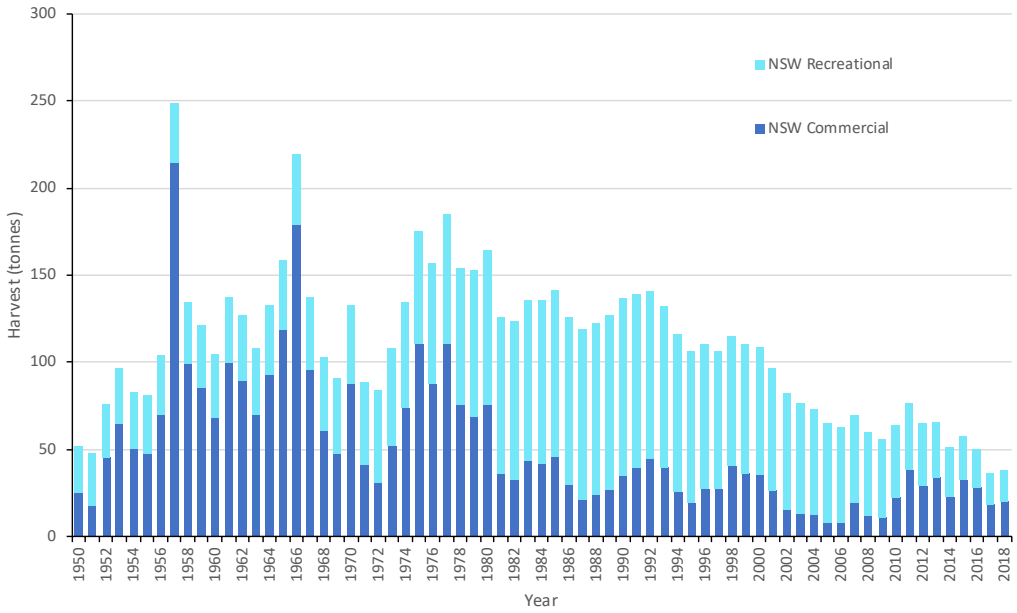


Figure 3. Reconstructed catch history from commercial and recreational fishing in NSW 1950/51 to 2018/19.

There are no data on Aboriginal harvest.

Fishing effort trends

Commercial

Commercial fishing effort on teraglin 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 handlining reported for when Teraglin were also reported in a month have declined from nearly 4,000 during 1997/98 to fewer than 2,000 in recent years (Fig. 4). More accurate estimates of fishing effort are available after 2009/10 and show that the number of days using handlining on which Teraglin were landed have been relatively stable at around 900 since that time (Fig. 5).

There has been a substantial decline in the number of days fished using the method of handlining in ocean zones 2 and 3 since 1997 (Fig. 6).

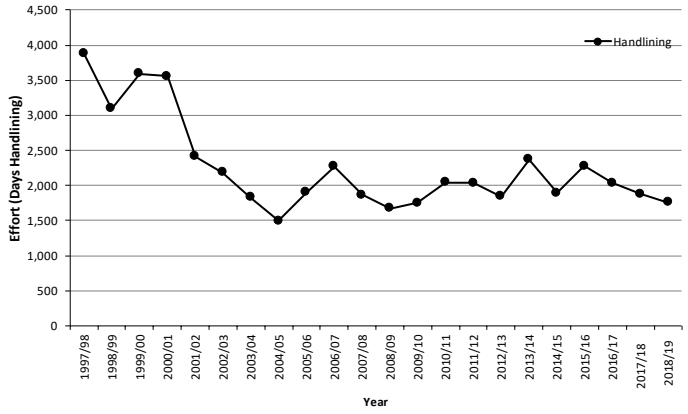


Figure 4. Annual reported days fished for months when Teraglin were landed by handlining 1997/98 to 2018/19

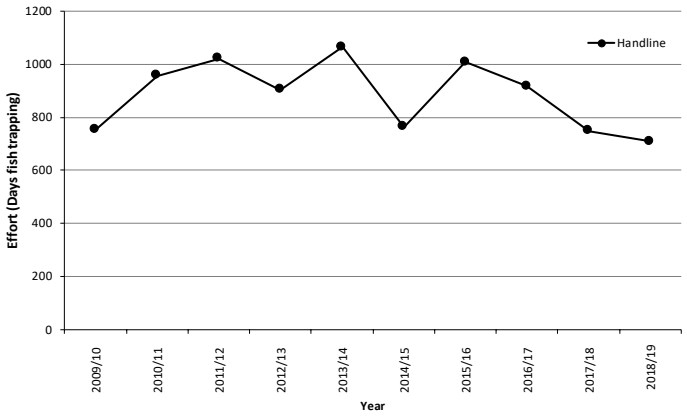


Figure 5. Annual reported days fished when Teraglin were landed by handlining 2009/10 to 2018/19.

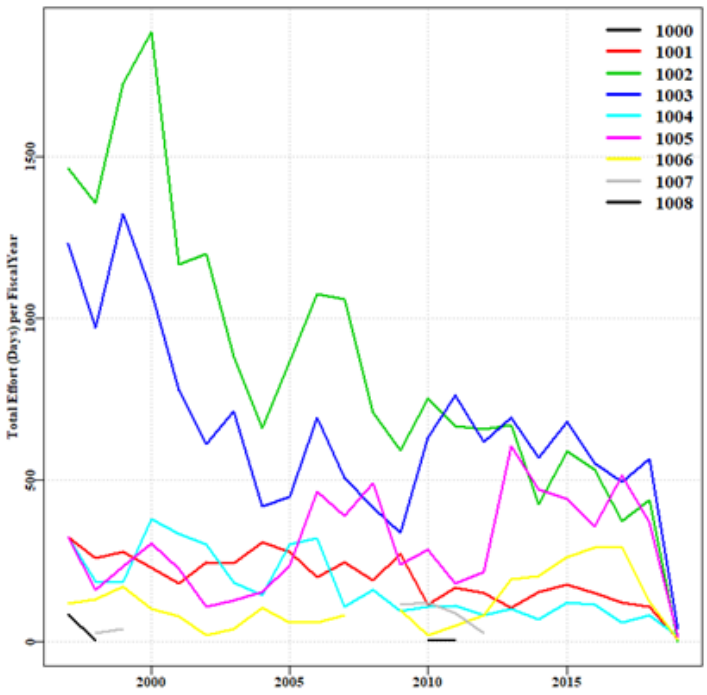
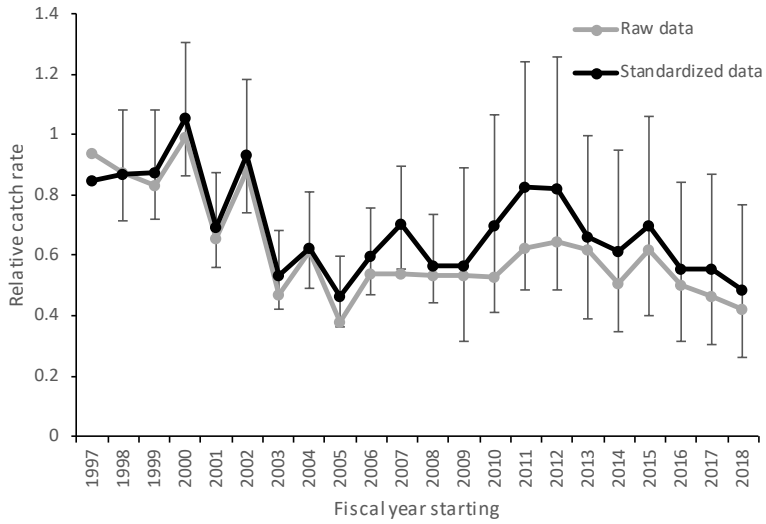


Figure 6. Annual reported days fished in a month when Teraglin were landed by handlining 1997/98 to 2018/19 by Ocean Zone.

Catch rate trends

Catch rates of Teraglin using the method of handlining were standardized using 2 series of data. Firstly, catch rates in terms of kg/day fished using the method of handlining when all days in a month using this method are included, for the periods 1997/98 to 2008/09 and 2009/10 to 2018/19 were analysed 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. Secondly, catch rates in terms of kg/day fished using the method of handlining were analysed for the period 2009/10 to 2018/19 using the data as reported. Again, catch rates were standardized for month, authorized fisher and latitude of landings. Standardization was done using the r-package 'cede'.

Standardized catch rates since 1997/98 have fluctuated but show an overall decline, noting slight increases during 2011/12 and 2012/13 (Fig. 7). Standardized catch rates since 2009/10 have remained relatively stable with no overall trend (Fig. 8). The trends since 2009/10 are very similar using both data sets and imply some confidence that the 1997/98 onwards dataset is representative of the fishery.



'Figure 7. Standardized catch rates (kg/day handlining) with standard errors for the period 1997/98 to 2018/19.

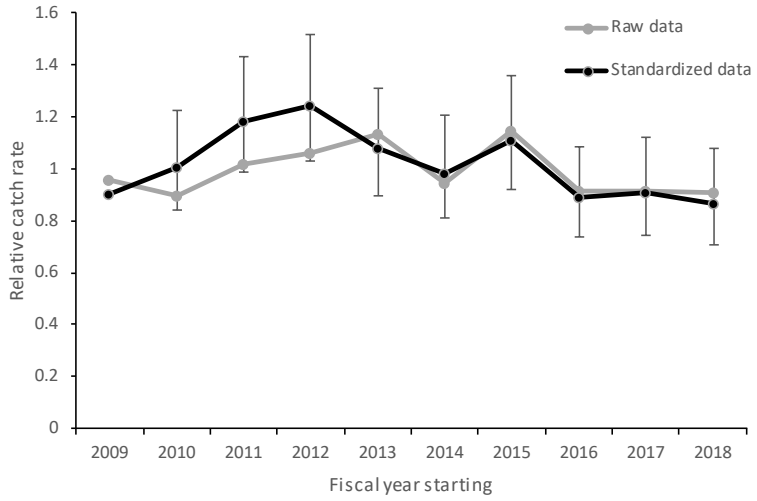


Figure 8. Standardized catch rates (kg/day handlining) for the period 2009/10 to 2018/19.

Eastern Australian biological stock

Catch rate trends

Harvest across the entire biological stock could only be compiled from 1997 onwards, as Teraglin were not a listed species on commercial logbook in Queensland prior to this. Queensland recreational harvests were estimated through surveys during 2000, 2010 and 2012, with harvests between these years being estimated linearly and a constant at the 2012 level after that time. The method for NSW based on Kleisner et al. (2015) was used to estimated harvest 1997 to 2000.

Harvest is dominated by NSW, averaging 76% of the total harvest each year since 1997/98 (Fig. 9). Landings show an overall decline since 1997/98.

Figure 9. Catch history of Teraglin across the entire biological stock from 1997/98 to 2018/19.

Stock Assessment – list of indicators

Year of most recent assessment	2020
Assessment method	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 Surplus Production Model. 3. Standardized catch rates. 4. Trends in size composition in the landed commercial catch 1970s to 2013/14. 5. Pattern of age composition in commercial catch 2011/12. 6. Mortality estimates.
Main data inputs	1. Annual total landed catch of Teraglin by the NSW fishery (commercial and recreational) from 1950/51 – 2018/19.

<table>
<tr>
<td></td>
<td>2. Annual total landed catch of Teraglin stock wide from 1997/98 – 2018/19. Standardised commercial CPUE 1997/98 to 2018/19 weighted by jurisdiction.
Biological Parameters:
<table>
<tr><td>maxage the maximum age</td><td>14</td></tr>
<tr><td>M natural mortality</td><td>0.44</td></tr>
<tr><td>Linf vB asymptotic maximum length</td><td>73.8</td></tr>
<tr><td>K vB Brody growth coefficient</td><td>0.2</td></tr>
<tr><td>t0 theoretical age at zero length</td><td>-1.9</td></tr>
<tr><td>Waa weight at age a parameter</td><td>1.23E-05</td></tr>
<tr><td>Wab weight at age b parameter</td><td>2.930565</td></tr>
<tr><td>M50a age at 50% maturity</td><td>1</td></tr>
<tr><td>deltaM diff between ages at 50 and 95% maturity</td><td>1</td></tr>
<tr><td>sela50 age at 50% selectivity</td><td>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 handlining 1997 to 2018.
4. Size composition in landed commercial catch 1970s to 2018/19.
5. Age composition in commercial catch 2011/12.
6. Mortality estimates derived from catch curves and empirical equations based on maximum age (Then et al., 2015).</td>
</tr>
<tr>
<td>Key model structure and assumptions</td>
<td>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. This is consistent with the life-history parameters of Teraglin as described in FISHBASE.</td>
</tr>
</table>

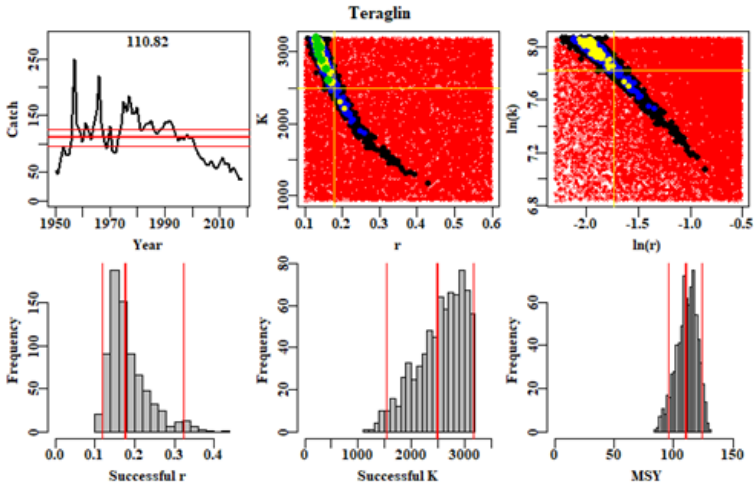
	2. The age-structured production model is a surplus production model based upon an age-structured model of production. A 3 parameter model was chosen as the stock is assumed to have been fished down considerably by 1997. Initial parameters for the average unfished recruitment level, the standard deviation of the errors around the CPUE data and an initial depletion estimate for 1997 were set as 19, 0.15, and 0.3. 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 2013/14 – assuming these are representative of the fishable stock. 5. Pattern of age composition in commercial catch 2011/12 – assuming this is representative of the fishable stock. 6. Mortality estimates – assuming the catch curve was 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 - 0.32; and *K* = 1,707 t – 3,166 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 in NSW 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 these assessments.

	Landed catch Fishing effort Size composition in landed catch Age composition Mortality rates
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} (B_{MSY}). 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.Teraglin CMSY assessment results using NSW data 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.	

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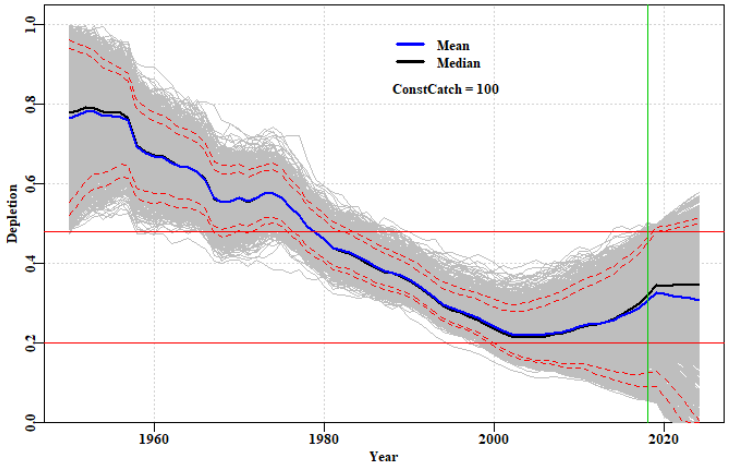
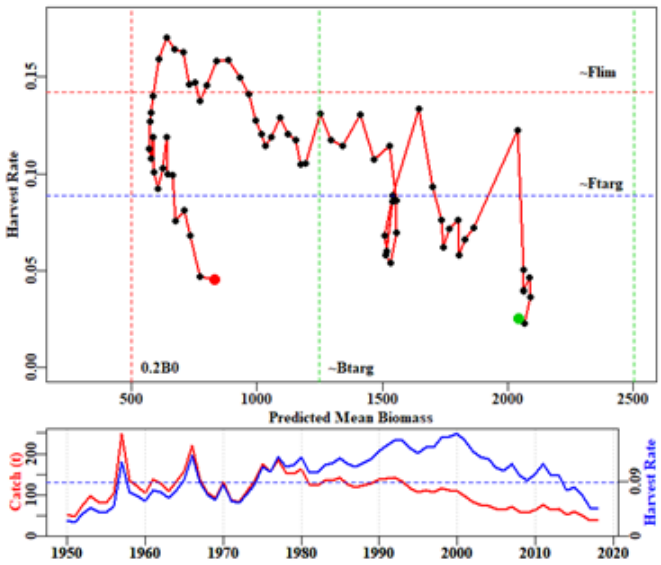
1.Range of depletion trajectories for successful r-K pairs, showing mean and median annual depletion and 80th and 90th percentiles (dashed lines). The lower red line is the 0.2B0 limit reference point, while the upper is the Schaefer BMSY (0.5B0) target reference point. The vertical green line indicates 2018/19, the final year for which data are available. Projected depletion levels are shown for 5 years thereafter at constant catch at 100 t.



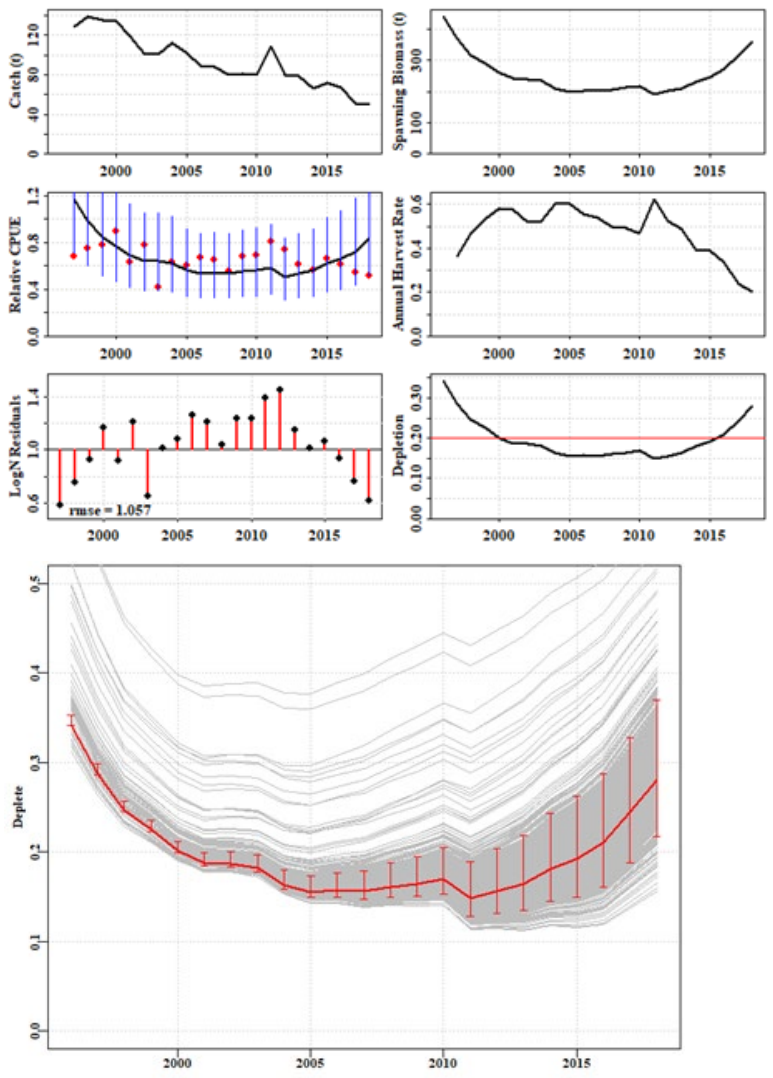
1. Teraglin stock status trajectory from 1950/51 – 2018/19, showing annual stock status in estimated biomass (t) and harvest rate.

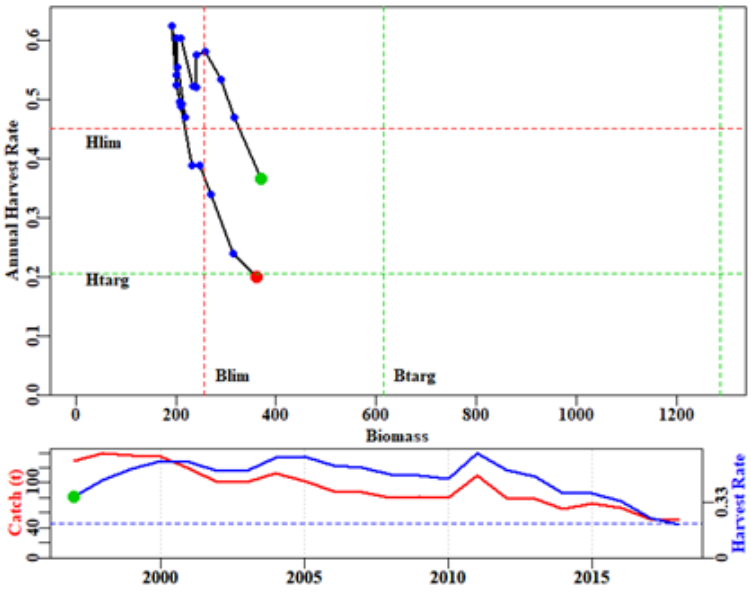
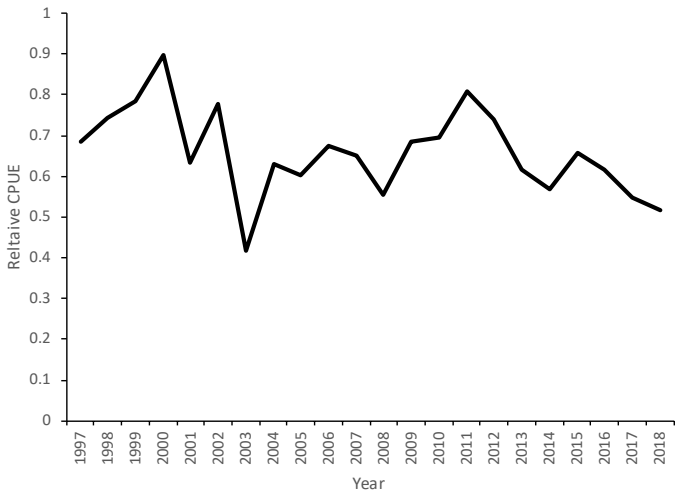
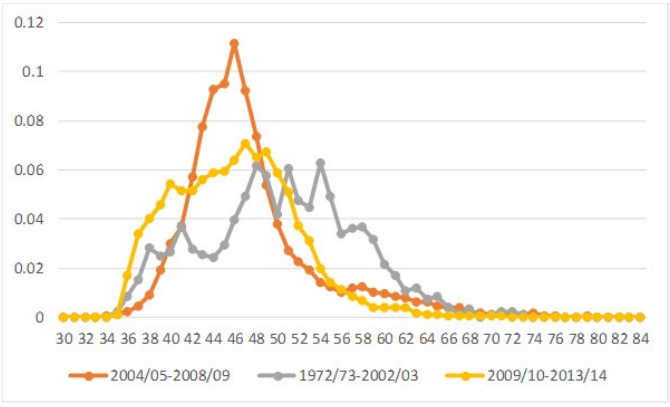
Reference levels are shown for biomass target (B_{MSY}) and limit ($0.2B_0$) reference levels, and for the corresponding harvest rates that should keep biomass at or above the target F_{targ} (F_{MSY}) and above the limit F_{lim} (F_{B20})
The start of the trajectory in 1950 is indicated by a green point and final year 2018/19 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 Teraglin Catch-MSY stock assessment, showing median (50%) estimates for r, K, MSY and Current Depletion, with 95% intervals.

Parameter	2.50%	50.00%	97.50%
r	0.11	0.17	0.32
K	1707	2620	3166
MSY	94	111	126
CurrDepl	0.08	0.35	0.50

2. Teraglin age-structured production model assessment using combined data from NSW and QLD results showing catch, standardized CPUE with model fit, spawning biomass, annual harvest rate and relative depletion levels.	 The bootstrapped trajectories of stock depletion with 95% confidence intervals.

2. Teraglin stock status trajectory from 1997/98 – 2018/19, 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 2018/19 by a red point. The red line on the bottom plot is catch and the blue line is harvest rate.	
3. Catch rates stock wide. Catch rates (standardized NSW and QLD catch rates weighted by the relative state's catch each year) were slightly higher during late 1990s and early 2000s but have been relatively stable since those years.	
4. Size composition in landed commercial catch 1970s to 2013/14	

5. Age composition in commercial catch 2011/12.	
6. Mortality estimates derived from catch curve analysis in 2011/12 and the empirical equation of Then et al. 2015, using a maximum age of 14 years.	

Region	Age range	*Z*	*M*	*F*
Combined	2 to 8	0.85	0.44	0.42
South	2 to 7	1.13	0.44	0.69
North	2 to 8	0.78	0.44	0.35

Biomass status in relation to Limit	The Catch-MSY model using NSW data since 1950 indicated that the biomass fell steadily between the 1950s and around 2000 where it approached the limit reference point, before steadily increasing to approximately 0.35 B_0 in 2018/19. The method is a purely deterministic model assuming that changes in catch reflect changes in abundance. Therefore, the recent periods of low catches will result in a predicted increase in biomass. 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 rather than just accepting outputs from the catch-MSY method. The Age-Structured Production Model using stock wide harvest data from 1997/98 onwards and a starting biomass estimate of 0.30 B_0 (as estimated in the Catch-MSY model above for 1997/98) indicated that biomass declined to below the limit reference point before increasing to above it at around 0.28 (95% CIs 0.21 to 0.37) B_0 in 2018/19. It is noted that the model did not fit the CPUE data well and consequently that the trends in biomass post 1997/98 were unlikely to be exact; however there are no indications that biomass would have declined substantially since that time. The stock wide standardized catch rates indicate that the available biomass of Teraglin has declined slightly since 1997/98 and been variable but with no obvious trend since around 2000.

<table>
<tr><td></td><td>The weight of evidence is that the biomass of Teraglin declined during the late 1990s and has since increased slightly to be at around 0.28 B_0 in 2018/19 which is above the limit reference point of 0.2 B_0.</td></tr>
<tr><td>Fishing mortality in relation to Limit</td><td>Estimated mean harvest rate exceeded F_{targ} between the 1970s to early 2000s and declined thereafter so be below that since the early 2010s.

The harvest in NSW has declined substantially since the 1970s The Catch-MSY model estimated that landings exceeded the MSY frequently until the mid-1980s and has been beneath that level since.

Commercial fishing effort has declined since the late 1990s but has been relatively stable since the early 2000s.

The size composition in the landed catch indicates a substantial decline in the proportion of larger fish in landings since the 1970s.

The single age composition from 2011/12 indicates considerable age-class truncation, with relatively few fish greater than 3-4 years of age.

Estimates of mortality rates suggest that in 2011/12 Fishing mortality was similar to Natural mortality, noting the high and least-precautionary estimates of M were used.

The weight of evidence is that Fishing mortality was excessive during the 1970s to early 2000s. Since that time fishing mortality has declined substantially across the stock to be at a level under which the population is increasing.</td></tr>
<tr><td>Previous SAFS stock status</td><td>Stock status for Teraglin has not previously been reported in SAFS.

Within the NSW assessment framework, Teraglin 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>Undefined</td></tr>
<tr><td>2005/06</td><td>Undefined</td></tr>
<tr><td>2006/07</td><td>Undefined</td></tr>
<tr><td>2007/08</td><td>Fully Fished</td></tr>
<tr><td>2008/09</td><td>Fully Fished</td></tr>
<tr><td>2009/10</td><td>Fully Fished</td></tr>
<tr><td>2010/11</td><td>Fully Fished</td></tr>
<tr><td>2011/12</td><td>Uncertain</td></tr>
</table>
</td></tr>
</table>

		2012/13	Uncertain	
		2013/14	Uncertain	
		2014/15	Uncertain	
Current SAFS stock status	The above evidence indicates that the biomass of this stock is unlikely to be depleted and that recruitment is unlikely to be impaired. The above evidence indicates that the current level of fishing mortality is unlikely to cause the stock to become recruitment impaired. On the basis of the evidence provided above, the entire biological stock is classified as a sustainable stock.			

Qualifying Comments

There is considerable uncertainty in the estimates of biomass depletion derived from catch data using both the Schaefer production model-assisted Catch-MSY analysis and the Age Structure Surplus Production Model, with some model runs estimating the stock to be below the limit reference point. Nevertheless median biomass depletion estimates are above this at around 28% B_0. It is noted that basing an assessment just using commercial fishing data would conclude that the stock was depleted to below the limit reference point, but that adding the recreational harvest, which is the majority of the harvest, estimates a far more optimistic situation. The fact that the recreational harvest data was drawn from only 3 surveys that are not directly comparable and of dubious quality for Teraglin, with pre 2000 estimates based on a generic hindcasting method (Kleisner et al., 2015), adds considerable uncertainty to the assessment. Despite this, the weight of evidence approach suggests that a Sustainable stock status is appropriate.

References

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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.