Stock Status Summary 2021

NSW Stock Status Summary – Giant Mud crab *(Scylla serrata)*

Assessment Authors and Year

Johnson, D. 2020. NSW Stock Status Summary 2018/19 – Giant Mud Crab (*Scylla serrata*). NSW Department of Primary Industries. Fisheries. 8 pp

Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Giant Mud Crab is currently assessed as Sustainable for the NSW component of the stock.

Stock Structure

Genetic evidence suggests that there are at least two biological stocks of Giant Mud Crab (GMC) in Australian waters: one to the west and another to the south east of the Torres Strait (Gopurenko & Hughes, 2002), referred to as the Northern Australian and East Coast biological stocks, respectively (Grubert et al., 2018).

Stock Status – New South Wales

Catch Trends

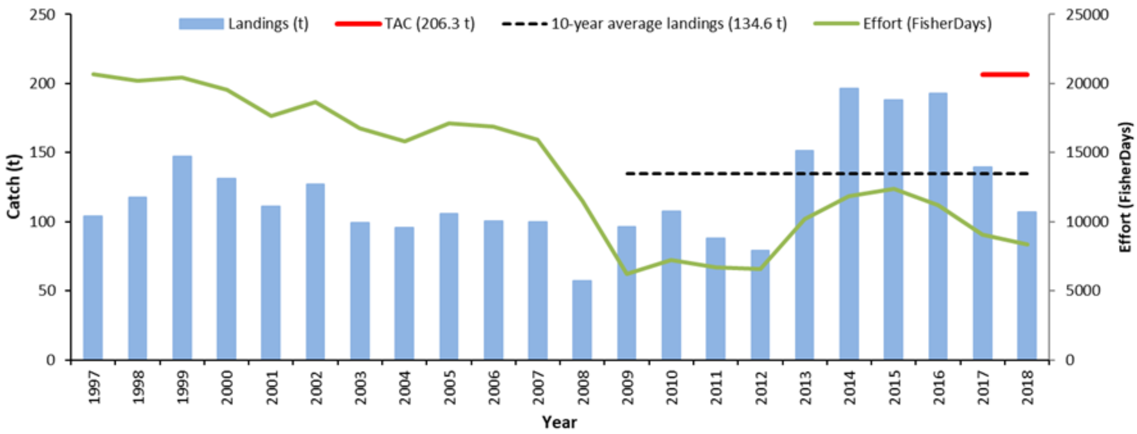


Figure 1. Summary of commercial reported landings of GMC for NSW from 1984–85 to 2018–19 (Blue bars), 10-year average landings (dashed line), total allowable commercial catch (TAC) and, effort in fisher days (green line).

The Estuary General Fishery (New South Wales) (EGF) accounts for approximately 17 per cent of the commercial harvest from the East Coast Giant Mud Crab biological stock (Grubert et al., 2018), with the annual catch composition by sex being very close to 1:1 (49 per cent female, 51 per cent male).

The catch by the EGF increased 70 per cent between the 2010–11 and 2014–15 financial years (from 111 t to 189 t, respectively), and the catch for the 2018–19 financial year was 107 t. Catch in the EGF (as of 1 December 2017) is controlled through an TAC of 206.3 t, with catch allocations based on current shareholdings.

Recreational and Indigenous

A recent survey of recreational fishing in New South Wales (which may include some harvest by Indigenous fishers) indicated that the non-commercial take accounts for around 20 per cent of the overall Giant Mud Crab harvest in this state [Murphy et al., 2020] (using a regional weight multiplier estimated at 0.70 kg per crab).

Catch rate trends

GMC standardised catch rates were predicted from generalised linear models (GLM). The GLM statistical modelling provided an estimate of mean catch rates that were corrected for a variety of variables that bias raw data. The GLM models were fitted using the statistical software packages Cede (Haddon et al., 2018) and R (R Development Core Team 2017). Explanatory model terms considered different catch rates between fishing years, months, EGF management zones, individual fisher operations (Authorised fisher ID) and, their transformed fishing effort.

Standardised commercial catch rates (in mean CPUE kg day-1) is likely to be the most reliable index of relative abundance for GMC. For recent data analysed as mean daily catch rates (available from 2009–10 to 2018–19), catch rates (regions combined) have remained stable and were above the 9-year average from 2013–14 to 2017–18. However, catch rates within the four main regions of the fishery are variable. For example, catch rates in Regions 1and 2 were above long-term averages in 2018–19, while catch rates in regions 3 and 4 were below averages. The observed decline in CPUE kg.day-1 in 2018–19 (EGF and Regions 1-4 pooled) can partly be explained by the total catch and subsequently, the proportion of total catch taken within individual regions.

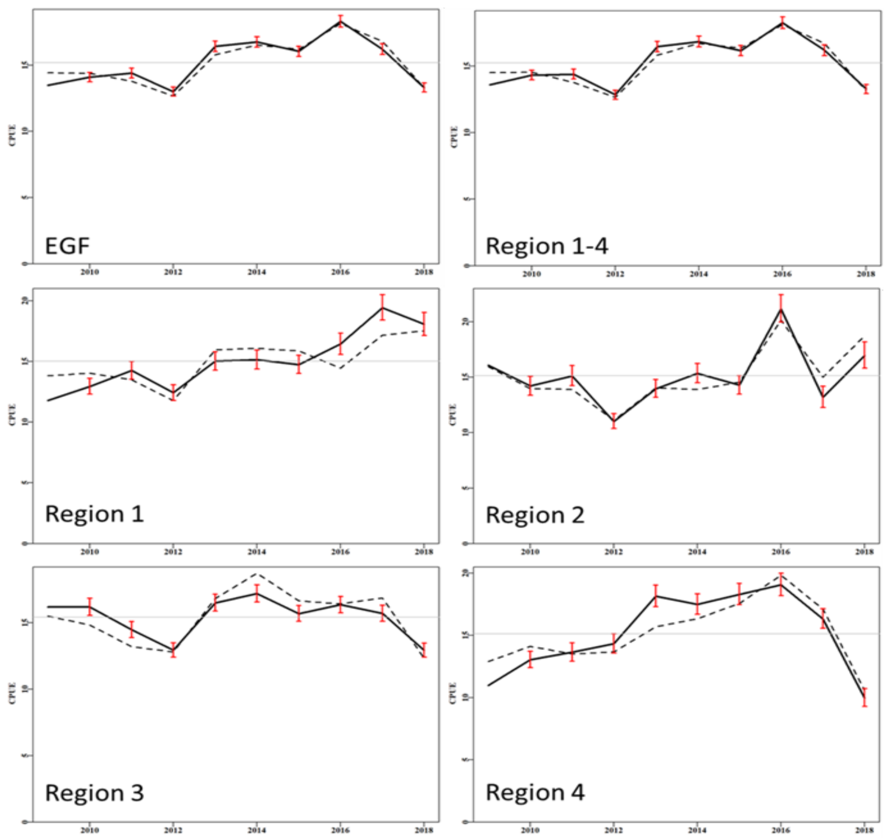


Figure 2. Standardised commercial catch rates from EGF, Regions 1-4 pooled and separate (nominal scale; CPUE kg day-1 from daily records). The dashed line is the geometric mean CPUE while the solid line with 95% confidence intervals is the standardised CPUE. The horizontal line represents the average catch rate (2009–10 to 2018–19).

Stock Assessment Methodology

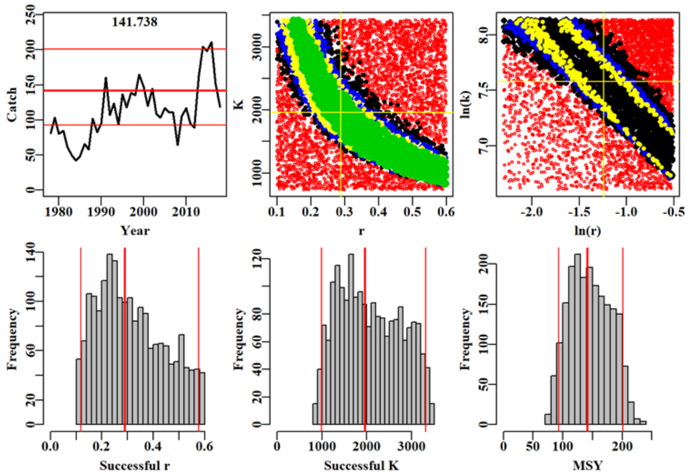
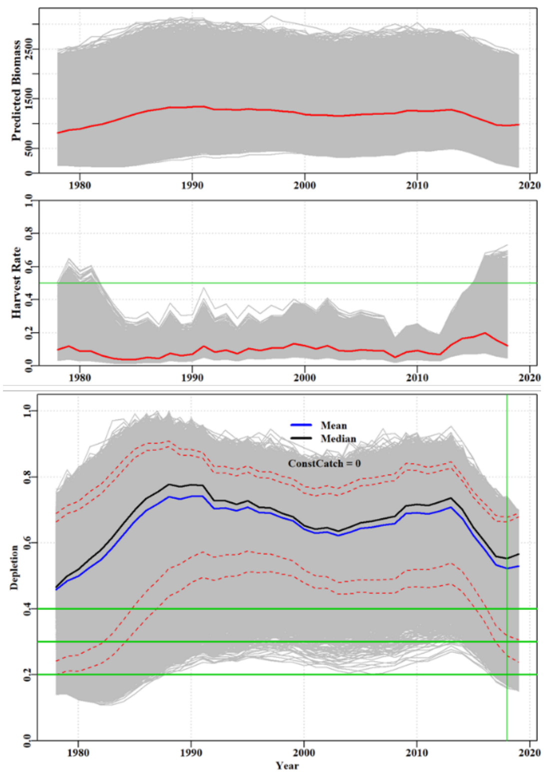
Year of most recent assessment	2020
Assessment method	Weight of evidence approach, including; standardised catch rates, Catch-MSY model-assisted catch-only assessment and, Bayesian state-space implementation of the Schaefer surplus production model (BSM).
Main data inputs	1. Landed commercial catch -1978–79 to 2018–19. 2. CPUE- kg.FisherDay^{-1} 2009–10 to 2018–19 (daily). 3. CPUE - kg.FisherDay^{-1} 1984–85 to 2018–19.
Key model structure and assumptions	1. Standardised catch rates (using cede v. 0.04) (Haddon *et al*., 2018). *Assumptions*: that annual catch rates are a relative index of abundance and not unduly influenced by other factors that are not accounted for through standardisation. 2. Catch-MSY model-assisted catch-only assessment (Martell & 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. *Assumptions*: Estimated ranges of the population growth rate parameter (r) and carrying capacity (*K*) of the stock are pre-determined through an assumed resilience; the underlying population biomass model is very generic and simplistic, with parameters that remain constant through time; the model outcomes are quite dependent on the lower bound of *r* selected (Martell and Froese 2013). '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. 3. Bayesian state-space implementation of the Schaefer surplus production model (BSM) using CMSY+ and BSM (Froese *et al*., 2019). The main advantage of BSM compared to other implementations of surplus production models is the focus on informative priors and the acceptance of short and incomplete (= fragmented) catch-per-unit-of-effort (CPUE) data (See Froese et al., 2017 for full description). *Assumptions*: Productivity models such as used by CMSY assume average recruitment across all stock sizes, including stock sizes below half of B_{msy}. However, if recruitment is indeed reduced at lower stock sizes, then production models and CMSY will overestimate production of new biomass and will underestimate exploitation rates.

Sources of uncertainty evaluated	The effect of four different constant catch scenarios on the 5-year projections of estimated biomass and harvest rate trajectories. The impact of recreational harvest ranging from 10-30% of reported commercial landings on Catch-MSY outputs.

Status Indicators and Limits Reference Levels

Biomass indicator or proxy	None specified in a formal harvest strategy. For the purposes of this assessment the mean estimated biomass depletion (as a percentage of the estimated maximum biomass, K) from modified Catch-MSY analyses (e.g., Martell & Froese 2013) was selected as a proxy.
Biomass Limit Reference Level	None specified in a formal harvest strategy. For the purposes of this stock assessment the values of 20% of estimated maximum biomass for the limit reference point (B_{lim}) and 48% of estimated maximum biomass as the target reference point (B_{targ}) were selected.
Fishing mortality indicator or proxy	None specified in a formal harvest strategy. For the purposes of this stock assessment the estimated harvest rate from modified Catch-MSY analyses was selected.
Fishing mortality Limit Reference Level	None specified in a formal harvest strategy. For the purposes of this stock assessment the estimated harvest rate corresponding to 20% of estimated maximum biomass for the limit reference point (H_{lim}) and the estimated harvest rate corresponding to when the stock is a 48% of estimated maximum biomass for the target reference point (H_{targ}) were selected.

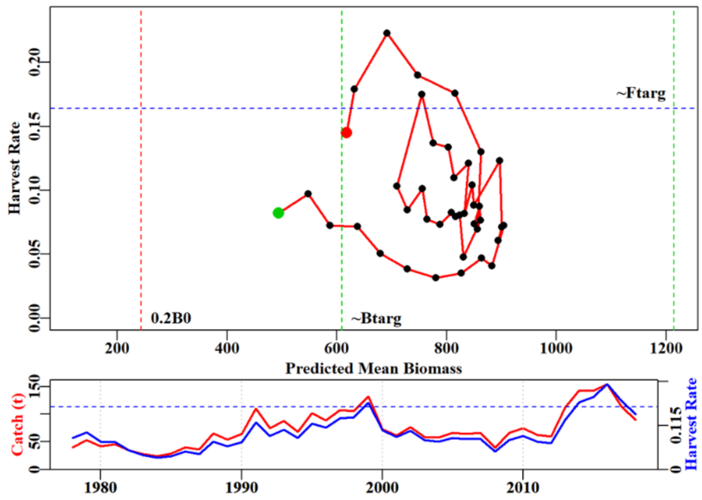
Stock Assessment Results

2. GMC CMSY 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.	
2. Range of depletion trajectories for successful *r*-*K* pairs, showing mean and median annual depletion and 80th and 90th percentiles (dashed lines). The lower green line is the $0.2B_0$ limit reference point, while the upper is B_{MSY} $(0.4B_0)$ target reference point.	

2. GMC stock status trajectory from 1978 - 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} (FB_{20}).

The start of the trajectory in 1978 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.



	2.5%	50%	97.5%
Catch-MSY	0.268	0.534	0.802
CMSY+	0.208	0.357	0.535
BSM	0.444	0.590	0.715

Biomass status in relation to Limit

The assessment estimates biomass (B) to have been above B_{targ} from 1981–82 to 2017–18.

The mean estimate of current Biomass ranges from ~36 - 59% of B_0, with a 97.5% confidence interval (CI) of 21% - 80%. Current estimated mean B is above the B_{lim} level of $0.2B_0$ for all analyses. Based on BSM analysis, B in the last year (1, 650 t) is estimated to be greater than B_{msy} (1, 390 t).

Five-year stock projections at mean catch of ~140 t (average landings 1978–79 to 2018–19) indicate that B is predicted to increase slowly at that catch level.

Five-year stock projections at catch equal to the current TAC (~200 t) with recreational catches estimated at 20% of total harvest, indicate that B is predicted to decline below B_{targ}.

Fishing mortality in relation to Limit

Estimated mean harvest rate remained low from 1978–79 to 2013–14 and then increased rapidly, exceeding estimated F_{targ} in 2014–15. resulting in decreasing biomass over this period. Harvest rate declined from 2016–17 as a result of decreased catches and was estimated to be below F_{targ} in 2018–19. Based on BSM

	analysis, estimates of fishing mortality (F) and exploitation rate (F/F_{msy}) in 2018–19 were 0.09 (CI: 0.0 7 - 0.12) and 0.95 (CI: 0.64 - 1.64), respectively.
Previous SAFS stock status	2018 undefined.
Current SAFS stock status	Using the weight of evidence approach, GMC is considered to be sustainable.

Qualifying Comments

The modelling approaches used in the current assessment are very simplistic and generic; therefore, results should be interpreted with caution. There is high uncertainty in the estimates of biomass depletion, harvest rate and MSY derived from catch data using Schaefer production model-assisted Catch-MSY analysis.

A key assumption in the Catch-MSY analysis is the ability to define a reasonable prior range for the parameters of the Schaefer model. Estimated ranges of the population growth rate parameter (r) and carrying capacity (K) of the stock are pre-determined through an assumed resilience; the model outcomes are quite dependent on the lower bound of r selected (Martell & Froese, 2013). '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.

Catch-MSY modelling may perform poorly for short-lived species, particularly stocks characterised by episodic recruitment and long-term changes in productivity.

The uncertainty regarding the spatial variation in total removals hampers the interpretation of the modified Catch-MSY modelling results.

Likewise, the uncertainty around the accuracy of historical commercial catch data should be considered when interpreting the results of BSM modelling.

Part of the GMC population in New South Wales is protected through a minimum size limit (85 mm Carapace length) although the effectiveness of this measure is uncertain because the size at maturity of GMC in this jurisdiction is not known. Studies on the reproductive biology of GMC from different catchments in northern Australia have reported regional differences in size at sexual maturity (Knuckey, 1999). The life history of GMC in New South Wales may differ from populations elsewhere as this jurisdiction represents the southern limit of the species' typical distribution on the eastern seaboard.

Several "no take" zones (applying to all marine organisms) along the New South Wales coast afford some protection to GMC and result in higher crab densities in the closed areas, size class distributions biased towards larger crabs, and spill over of crabs into adjacent fished areas (Butcher et al. 2014). However, these spatial closures are relatively small and fragmented, and their cumulative benefit on a fishery-wide scale has not been quantified.

References

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