Department of Primary Industries
Department of Regional NSW

NSW Stock Status Summary – 2023/24

Giant Mud Crab (*Scylla serrata*)

Assessment Authors and Year

Johnson, D.D. 2024. NSW Stock Assessment Report 2023/24 – Giant Mud Crab (*Scylla serrata*). NSW Department of Primary Industries - Fisheries. 69 pp.

Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Giant Mud Crab are currently assessed as **depleting**

Stock structure & distribution

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

Several "no take" zones (applying to all marine organisms) along the New South Wales (NSW) coast afford some protection to Giant Mud Crab and result in higher crab densities in the closed areas, size class distributions biased towards larger crabs, and spillover 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.

Scope of this assessment

This stock assessment report provides a determination of stock status of the NSW component of the East Coast Giant Mud Crab biological stock. The aims of this report are to; 1) define the stock structure of Giant Mud Crab in NSW and to provide a summary of the biology of the species; 2) assess the status of the NSW Giant Mud Crab stock; 3) summarise the available commercial fishery statistics; 4) outline limitations of available information and associated uncertainty; 5) provide some strategic direction for future research and assessment, and 6) support determination of a total allowable catch (TAC) for Giant Mud Crab in NSW estuarine waters, for the 2024-25 fishing season (1 July 2024 to 30 June 2025).

Biology

Length-at-maturity for female Giant Mud Crab is estimated to be ~138 mm carapace width (CW) in subtropical Australia (Heasman 1980), although there are no estimates published for south-eastern Australia (Taylor *et al*., 2023). Therefore, the proportion of the Giant Mud Crab population in New South Wales protected through the minimum size limit (85 mm carapace length (CL), ~127 mm CW) is uncertain. Studies on the reproductive biology of *S. serrata* from different catchments in northern Australia have reported regional differences in size at sexual maturity (Knuckey, 1999). The life history of Giant Mud Crab 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 (Taylor *et al*., 2023).

Using acoustic tags fitted to Giant Mud Crabs, Hewitt *et al*., 2022a identified that seasonal declines in temperature and heavy rainfall events which rapidly decrease conductivity as triggers for the spawning migration of mature female Giant Mud Crabs to oceanic areas. The offshore migration presumably occurs so the stenohaline larval stages are not exposed to brackish water (Hill 1994).

Fishery statistics

Catch information

Commercial

The NSW Estuary General Fishery (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 (Fig S1, 49 per cent female, 51 per cent male).

Reported landings by the EGF increased 88% between the 2010/11 and 2014/15 financial years (from 116.7 t to 204.6 t, respectively), and landings for the 2017/18 financial year were 192.7 t (Fig. 1). Catch in the EGF (as of 1 December 2017) is controlled through a TAC of 206.3 t, with catch allocations based on quota shareholdings. Post transition to quota management, reported landings decreased to 92.8 t in 2020/21, 103.9 t and 80.8 t in 2021/22 and 2022/23, respectively (Fig. 1). Reported landings from EGF Regions 1-4 account for approximately 95% of commercial Giant Mud Crab landings in NSW (Fig. S2). Estuaries including the Tweed River, Clarence River, Macleay River and Wallis Lake account for a large proportion of landings from Regions 1-4 (Fig. S3).

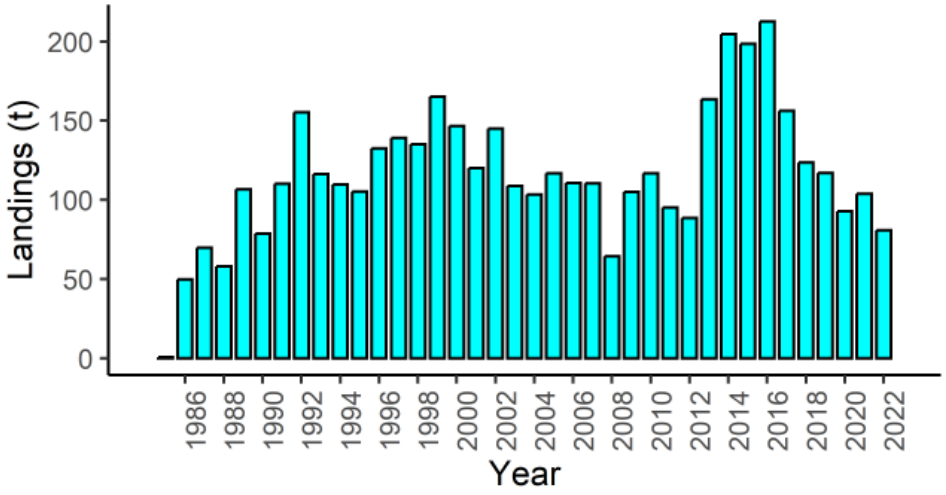

Figure 1. Annual reported commercial landings (t) from 1997/98 to 2022/23.

Recreational & Charter boat

Estimates of state-wide recreational catches are available from the National Recreational and Indigenous Fishing Survey completed in 2000/01(Henry & Lyle 2003) and New South Wales state-wide surveys completed in 2013/14 (West *et al*., 2015), 2017/18 (Murphy *et al*., 2020), 2019/20 (Murphy *et al*., 2022) and 2021/22 (Murphy *et al*., 2024).The 2013/14 estimate of ~20 t is based on (i) an estimated recreational retained catch of 30, 052 Giant Mud Crabs by NSW resident recreational anglers in 2013/14 (West *et al*., 2015); and (ii) an assumed mean weight of retained Giant Mud Crabs of 0.671 kg/ crab. This remains the most reliable estimate of annual recreational catch because survey estimates for 2017/18 (58, 212 crabs, ~39.0 t retained), 2019/20 (38, 620 total crabs) and 2021/22 (17, 107 crabs, ~10.2 t retained) applies only to 1-3 year recreational licence holders and fishers exempt

from holding a licence residing within households selected from the sampling frame (Murphy *et al*., 2020, 2022, 2024).

Indigenous

Although Aboriginal fishers harvest Giant Mud Crabs throughout NSW, there are no state-wide estimates of Aboriginal harvest. It is however, acknowledged and understood that fishing practices have been undertaken by Aboriginal people of many groups throughout NSW for many thousands of years and that fishing and related practices are valued by Aboriginal people for a wide range of reasons including subsistence (Smyth *et al*., 2018).

Illegal, Unregulated and Unreported

The level of Illegal, Unregulated and Unreported (IUU) fishing is unknown.

Fishing effort information

Reported effort (days) estimated from monthly catch and effort records slowly decreased from 20, 663 days in 1997/98 to 15, 933 days in 2008/09 then declined by ~45% in 2009/10 (6, 249 days) following the introduction of daily catch and effort reporting (Fig. 2). Reported effort exceeded 10, 000 days from 2013/14 to 2016/17. In response to revised management arrangements in the fishery (2017/18), effort decreased from 11, 387 days in 2016/17 to 9, 373 and 8, 705 days in 2018/19 and 2019/20, respectively. Reported effort in 2020/21 (6, 848 days), 2021/22 (7, 797 days) and 2022/23 (6, 757 days) was approximately 35% of the historical peak of 20, 663 days in 1997/98 (Fig. 2).

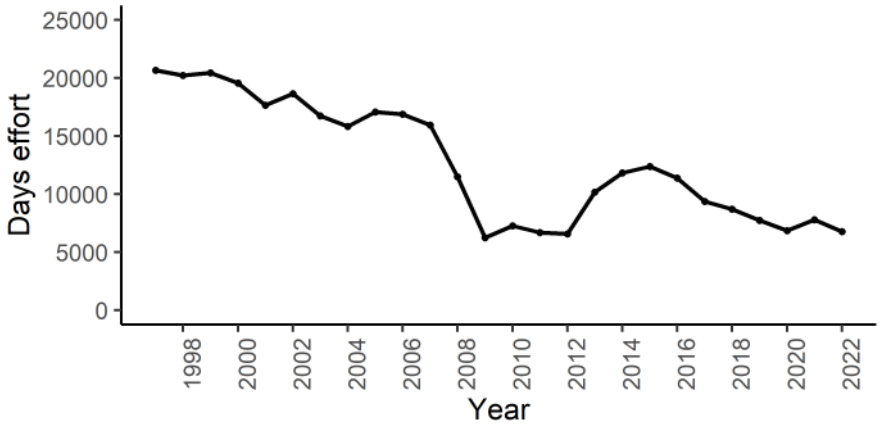

Figure 2. Reported days effort from 1997/98 to 2022/23.

Catch rate information

Following the introduction of daily catch and effort reporting in 2009/10, catch rates from the fishery ranged from 14.81 kg.Day^{-1} in 2010/11 to 17.46 kg.Day^{-1} in 2016/17 (Fig. 3). Following the transition to quota management in 2017/18, catch rates from the fishery continually declined from 15.19 kg.Day^{-1} (2017/18) to 11.33 kg.Day^{-1} and 10.45 kg.Day^{-1} in 2021/22 and 2022/23, respectively (Fig. 3). The declines in catch rates from the fishery from 2017/18 to 2021/22 are largely driven by declines in catch rates in estuary general region 4 (EGMC4) that accounted for 18 to 30% of reported landings during this period. In 2022/23, catch rates in EGMC2 and EGMC3 were ~30% lower than 2021/22. In contrast, catch rates in EGMC1 in 2022/23 (13.39 kg.Day^{-1}) were ~10% higher than 2021/22.

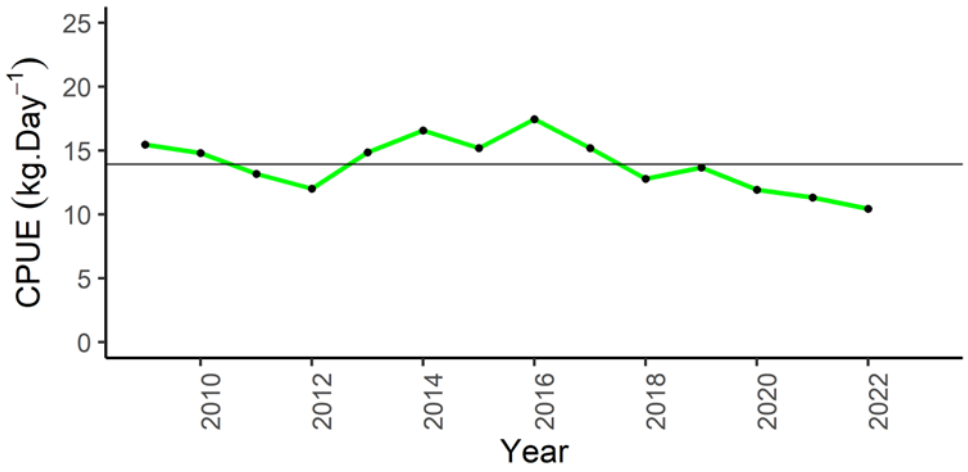

Figure 3. Nominal catch rates from EGF from 2009/10 to 2022/23. The horizontal line represents the average catch rate (2009/10 – 2022/23).

Stock Assessment

Stock Assessment Methodology

Year of most recent assessment:

2024

Assessment method:

Weight of evidence approach, including catch and standardised catch rates from the fishery and main regions.

Main data inputs:

The following raw data inputs were used in analyses:

- Commercial catch rates in kg.day^{-1} for the methods of crab trapping derived from fisher-reported monthly records by fiscal year (1997/98 - 2008/09);
- Commercial catch rates in kg.day^{-1} for the methods of crab trapping derived from fisher-reported daily records by fiscal year (2009/10 - 2016/17); and
- Commercial catch rates in kg.trap^{-1} for the methods of crab trapping derived from fisher-reported daily records by fiscal year (2017/18- 2022/23).

Key model structure & assumptions:

Annual catch rates were standardised using Generalised Linear Models (GLM) to account for the effects of year, month, fisher and EGMC region (fishery only) on three separate time series of data (1997/98 – 2008/09, 2009/10 – 2016/17 and 2017/18 – 2022/23) to account for changes in reporting and management arrangements. Catch rates were standardised for the fishery (EGMC All) and main regions separately. Models were fit using a lognormal distribution, with CPUE as the response variable, and year, month, fisher, and zone as explanatory terms (which were considered categorical variables). Estimated marginal mean values for each year and associated confidence limits were then calculated using the 'emmeans' package (Lenth, 2020) and rforCPUE (https://github.com/haddonm/rforcpue) in R (R Development Team, 2019). Residuals and assumptions of the model were checked using the 'DHARMa' package (Hartig 2020). Using these models, a manual backwards selection process, whereby each variable was removed one at a time and the Akaike information criterion values

(AIC) compared between competing models. *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.

Sources of uncertainty evaluated:

The effect of data selection on standardisations of daily data (kg.Day^{-1}) from 2009/10 to 2016/17 was investigated using the following criteria:

1. Minimum number of years in the fishery (1, 2, 4 & 8)
2. Minimum average catch per fisher (0.5, 1 & 2 t)
3. Minimum catch per record (1, 3 & 5 kg.Day^{-1})
4. Maximum catch per record (50, 75, & 100 kg.Day^{-1}).

The effect of data selection on standardisations of daily data (kg.Trap^{-1}) from 2017/18 to 2022/23 was investigated using the following criteria:

1. Minimum number of years in the fishery (1, 2, 4 & 6)
2. Minimum average catch per fisher (0.5, 1 & 2 t)
3. Minimum catch per record (1, 3 & 5 kg.Day^{-1})
4. Maximum catch per record (50, 75 & 100 kg.Day^{-1})

Status Indicators - Limit & Target Reference Levels

Biomass indicator or proxy	None specified in a formal harvest strategy. In the interim, for the purposes of this stock assessment a weight-of-evidence approach was used, which included: annual standardised catch rates from the fishery and four main regions.
Biomass Limit Reference Point	None specified in a formal harvest strategy. In the interim, the current catch rates were compared to the long-term averages of each time series.
Biomass Target Reference Point	None specified in a formal harvest strategy.
Fishing mortality indicator or proxy	None specified in a formal harvest strategy. In the interim, trends in the total fishing effort of the crab trapping sector of the EGF was used as an indicator of relative fishing pressure.
Fishing mortality Limit Reference Point	None specified in a formal harvest strategy.
Fishing Mortality Target Reference Point	None specified in a formal harvest strategy.

Stock Assessment Results

Standardised commercial catch rates (in mean CPUE kg-day^{-1}) for the fishery, EGMC1, and EGMC3 calculated from daily records fluctuated around the mean catch rate from 2009/10 to 2016/17 (Fig. 4 – left panel). Mean annual catch rates for EGMC2 were more variable and generally increased over time with the lowest catches rates during 2012/13 and highest catches during 2016/17 (Fig. 4 – left panel). For EGMC4, annual catch rates increased from 2012/13 to 2013/14 after which they remained stable to 2016/17. In contrast to the trend of increasing catch rates in the fishery, EGMC1, EGMC2 and EGMC4 from 2009/10 to 2016/17 (Fig. 4) coinciding with increased

reported commercial landings Fig. S1), annual catch rates in EGMC3 were stable despite a ~50% increase in reported landings (Fig. 4, Fig. S1).

Standardised commercial catch rates (in mean CPUE kg-trap^{-1}) for the fishery, EGMC1, EGMC3 and EGMC4 calculated from daily records declined from 2017/18 to 2022/23 (Fig. 4 – right panel). In contrast, mean annual catch rates from EGMC2 remained stable from 2017/18 to 2021/22 before sharply declining in 2022/23 (Fig. 4 – right panel). The trend of decreasing catch rates from the fishery and main regions coincides with a reduction in total commercial landings and effort over this period (Fig. 1, Fig. 2).

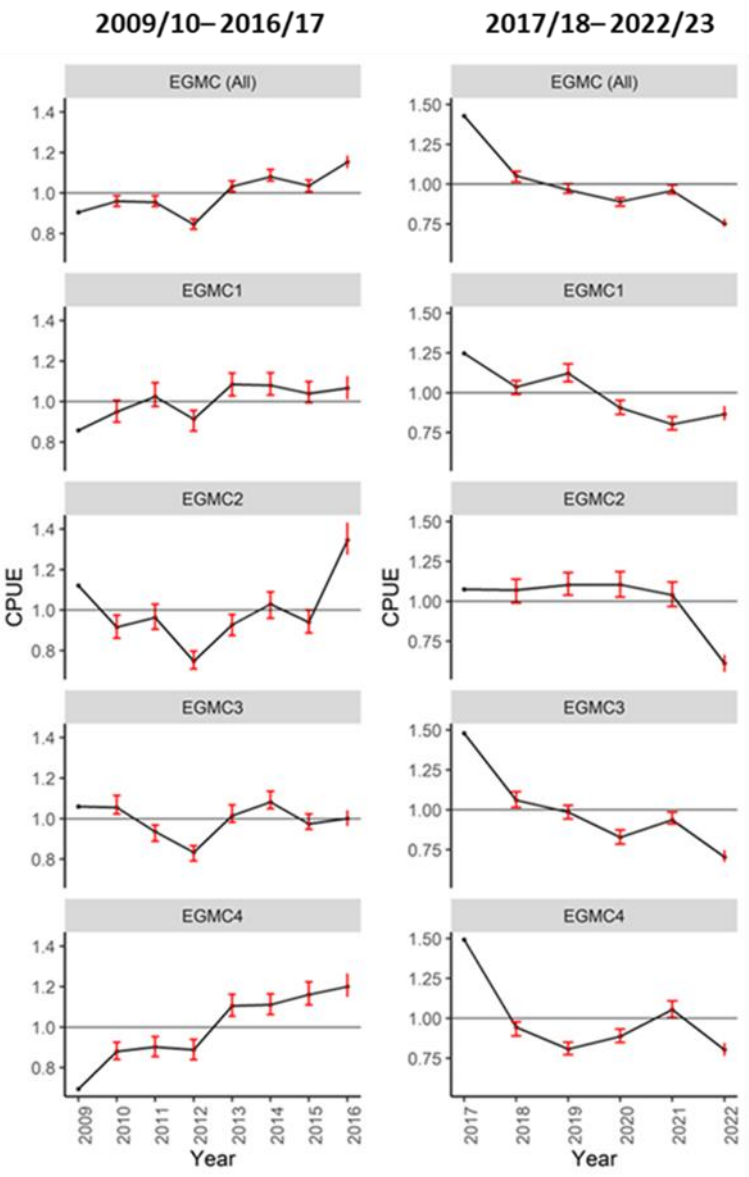

Figure 4. Standardised commercial catch rates (nominal scale) of Giant Mud Crabs for the method of crab trapping for the fishery and main regions from 2009/10 - 2016/17 (left panel) and 2017/18 - 2022/23 (right panel).

Stock Assessment Result Summary

Biomass status in relation to Limit	Results of the current assessment varied depending on the spatial-scale selected. For recent data analysed as mean catch rates (kg.day^{-1} & kg.trap^{-1}), standardised catch rates (regions combined) remained stable and above average from 2013/14 – 2017/18. From 2017/18, standardised catch rates from the fishery, EGMC1, EGMC3 and EGMC4 declined. Standardised catch rates from EGMC2 remained stable from 2017/18 to 2021/22, but declined sharply in 2022/23. Standardised catch rates from the fishery, EGMC1 and EGMC3 remained below average from 2020/21 to 2022/23. Weight-of-evidence provided is sufficient to support an understanding that the biomass of Giant Mud Crabs is at a level sufficient to ensure that on average, future levels of recruitment are adequate.
Biomass status in relation to Target	NA
Fishing mortality in relation to Limit	Reported days effort in 2020/21 (6, 757), 2021/22 (7, 439) and 2022/23 (6, 355) were approximately 35% of the historical peak of 20, 663 days in 1997/98.
Fishing mortality in relation to Target	NA
Current SAFS stock status	Sustainable (Saunders *et al*., 2021)
Current Queensland stock status	Sustainable (Saunders *et al*., 2021, Northrop *et al*., 2019)

Fishery interactions

Of the ~55 incidental species recorded from a fishery-wide observer-based assessment of the EGF Giant Mud Crab fishery completed over two fishing season, only one endangered, threatened and protected species was regularly trapped (n = 21, *Epinephelus coioides*) with all individuals released alive (Barnes *et al*., 2022).

Stakeholder engagement

NSW DPI Fisheries presented the current stock assessment to stakeholders in the EGF on the 5th March 2024, to outline the assessment process and provide an opportunity for feedback.

Qualifying Comments

A weight-of-evidence approach has been taken for this assessment. The weight of evidence supports and understanding that the biomass of Giant Mud Crabs is currently unlikely to be depleted and the current level of fishing mortality is unlikely to cause the stock to become recruitment impaired. Declines in catches and catch

rates in recent years is likely a result of substantial environmental changes impacting recruitment and high levels of fishing pressure in NSW estuaries.

Known or likely uncertainties in the key indicators were taken into consideration in ranking of the quality of key indicators, and in reaching a conclusion regarding stock status.

Using generalized additive mixed models (GAMM) and data collected from an extensive fishery-wide observer program, Hewitt *et al*., 2023 examined the influence of 'soak' (or immersion) time of commercial traps, water temperature, river flow, wind speed and lunar phase while controlling for gear configurations (e.g., number of entrances/escape gaps) and fisher 'skill' on catch rates of Giant Mud Crab in six of the highest catch estuaries in NSW. Soak-time had little effect on catch rates, while warmer temperatures generally enhanced catch rates. To a lesser degree, river flow, wind speed and the lunar phase also influenced catch rates. The inclusion of month as a term in standardisations of commercial catch rates (as above) accounts for seasonal fluctuations in water temperatures, likely driving higher catch rates in the summer months.

Particle dispersal modelling indicates a relatively high level of inter-jurisdictional connectivity for Giant Mud Crab, predominantly between Queensland and northern NSW (Hewitt *et al*., 2022b). The male-only harvest policy implemented in Queensland likely provides a degree of stability in spawning biomass, which may support higher levels of recruitment for northern NSW estuaries that are well connected with spawning in Queensland waters (Hewitt *et al*., 2022b, Taylor *et al*., 2023).

For the Qld fishery in 2017/18, catch-MSY model outputs estimated that exploitable biomass was likely to be 37 to 69% of unfished levels. The assessment quantified the risks of the biomass falling below the 20 per cent limit reference point as 'low' for the smaller harvest TACs projected and supported a total allowable commercial catch of 770 t for the east coast assuming recreational harvest represents ~21% of total removals (Northrop *et al*., 2019).

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Appendices

Supplementary figures

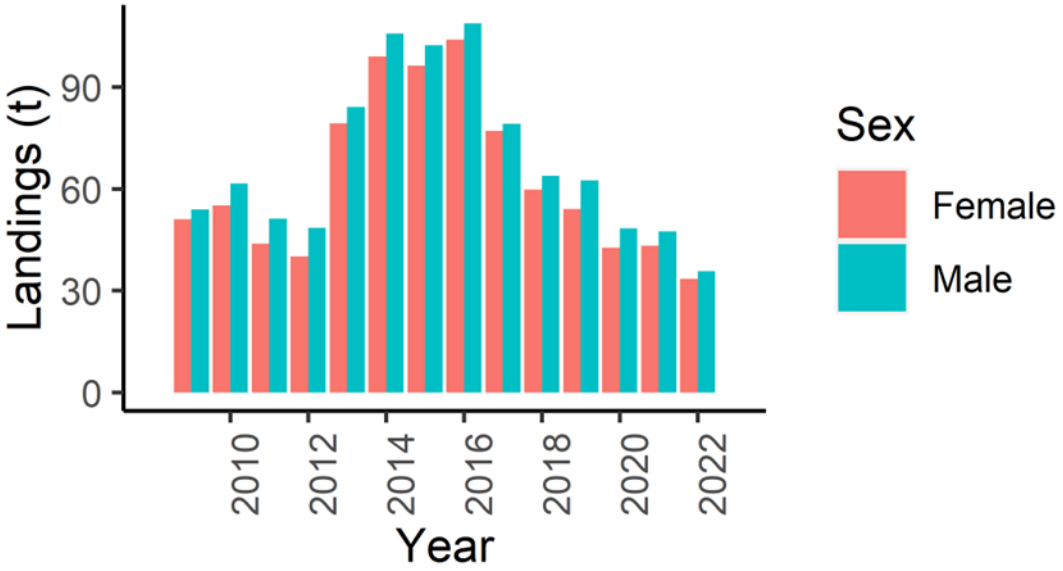

Figure S1. Reported annual landings of Giant Mud Crab by sex from 2009/10 to 2022/23.

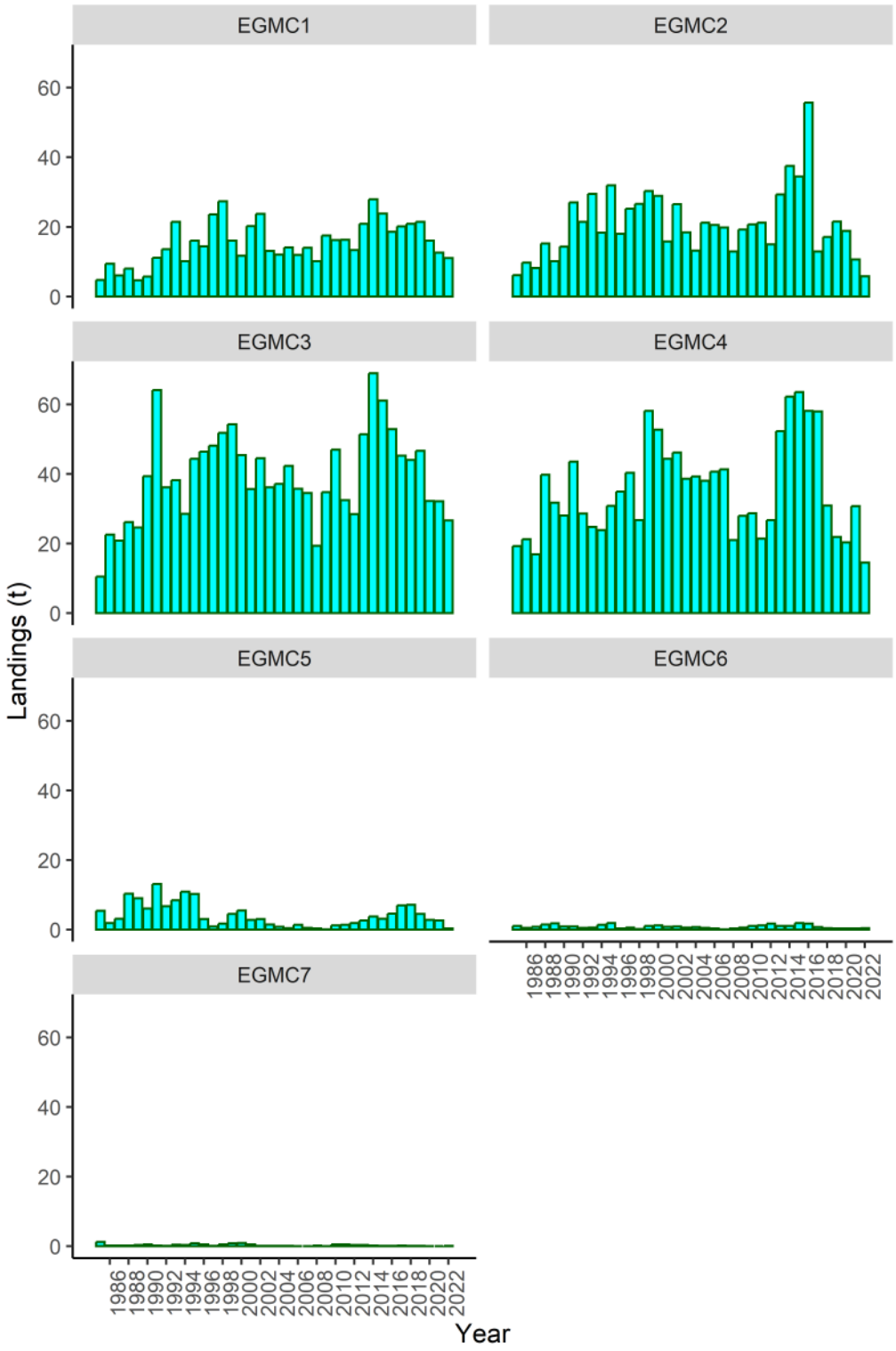

Figure S2. Reported annual landings (t) of Giant Mud Crab from estuary general fishery regions from 1997/98 to 2022/23.

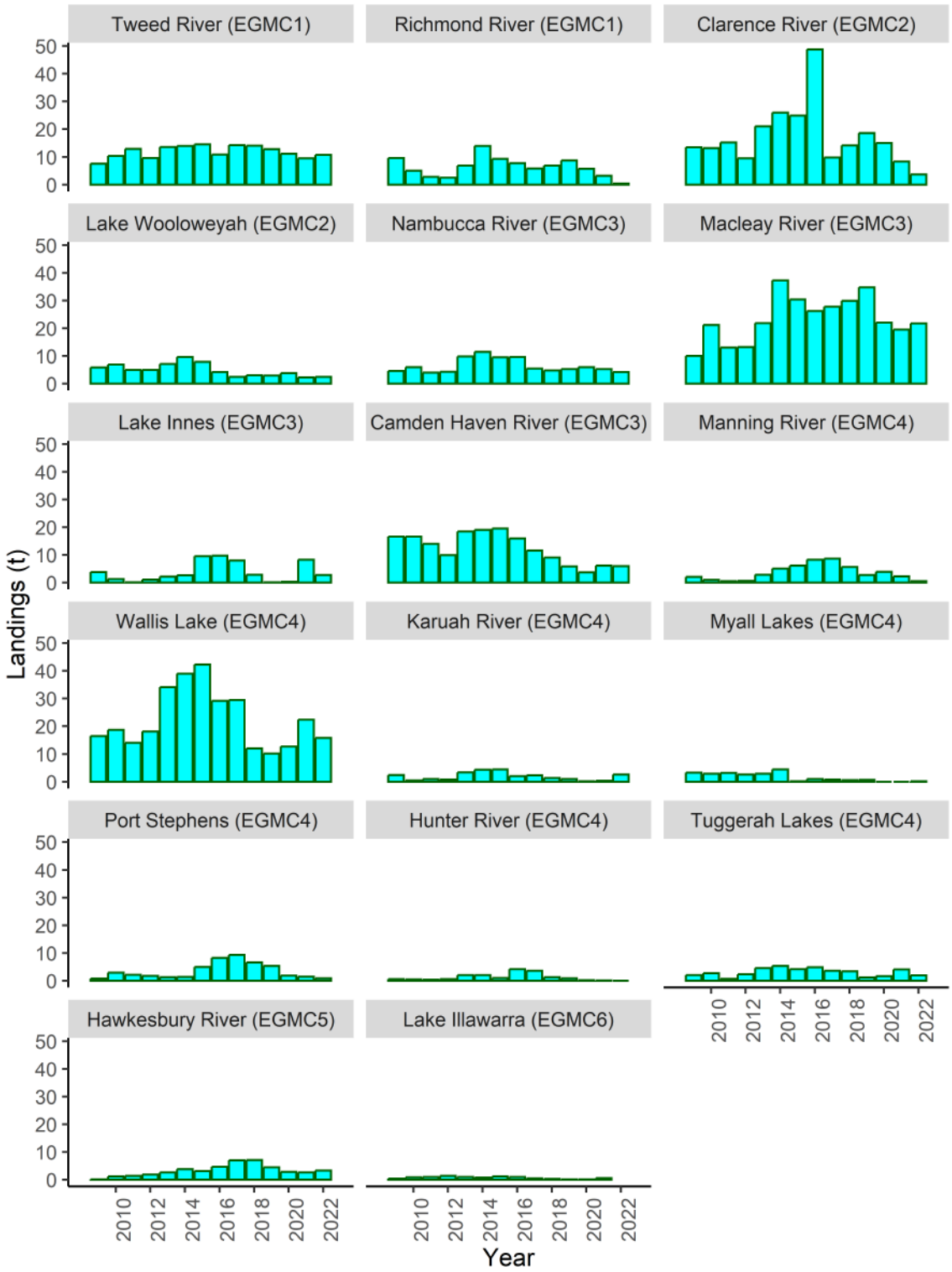

Figure S3. Reported annual landings (t) of Giant Mud Crab from main estuaries. Estuary general fishery region shown in parenthesis.