Stock Status Summary – 2022/23

NSW Stock Status Summary – Giant Mud Crab
(Scylla serrata)

Assessment Authors and Year

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Stock Status

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

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 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).

Several "no take" zones (applying to all marine organisms) along the New South Wales 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.

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 *S. serrata* 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 crabs to oceanic areas. The offshore migration presumably occurs so the stenohaline larval stages are not exposed to brackish water (Hill 1994).

FISHERY STATISTICS

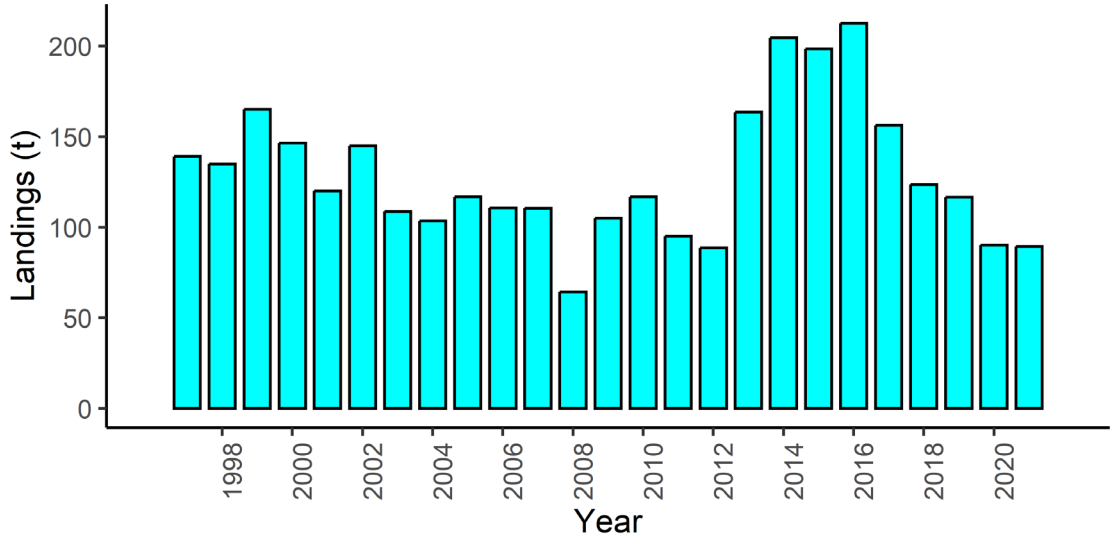
Catch information

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 (Figure 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 was 156.2 t (Figure 1). Catch in the EGF (as of 1 December 2017) is controlled through a total allowable catch (TAC) of 206.3 t, with catch allocations based on quota shareholdings. Post transition to quota management, reported landings decreased to 116.5 t in 2019/20, 90.2 t and 89.3 t in 2020/21 and 2021/22, respectively (Figure 1). Reported landings from EGF Regions 1-4 account for approximately 95% of commercial Giant Mud Crab landings in NSW (Figure S2). Estuaries including the Tweed River, Clarence River, Macleay River and Wallis Lake account for a large proportion of landings from Regions 1-4 (Figure S3).

Figure 1. Annual reported commercial landings (t) from 1997/98 to 2021/22.



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) and 2019/20 (Murphy et al. 2022).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) and 2019/20 (38 620 total crabs) applies only to 1-3 year recreational licence holders (Murphy et al., 2020, 2022).

Aboriginal cultural fishery

Although Aboriginal fishers harvest Giant Mud Crabs throughout New South Wales, 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).

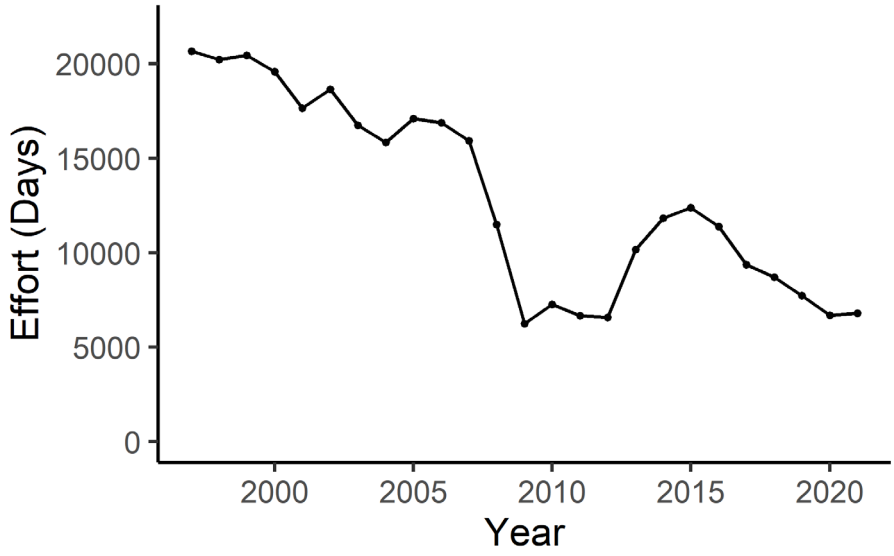
Illegal, Unregulated and Unreported

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 (Figure 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 9 372 and 8 704 days in 2018/19 and 2019/20, respectively. Reported effort in 2020/21 (6 685 days) and 2021/22 (6 809 days) was approximately 35% of the historical peak of 20 663 days in 1997/98 (Figure 2).

Figure 2. Reported days effort (Days) from 1997/98 to 2021/22

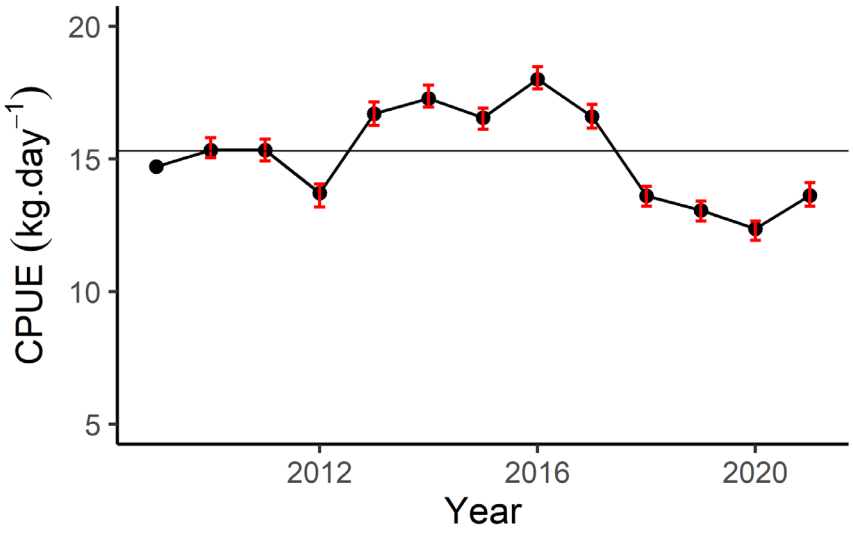


Catch Rate information

Giant Mud Crab 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 regions, individual fisher operations (Authorised fisher ID) and, their transformed fishing effort.

Catch rates (regions combined) remained stable and average from 2013/14 to 2017/18, but declined below average from 2018/19 to 2021/22 (Figure 3).

Figure 3. Standardised commercial catch rates from EGF with 95% confidence intervals. The horizontal line represents the average catch rate (2009/10 – 2021/22).



STOCK ASSESSMENT

Stock Assessment Methodology

Year of most recent assessment:

2023

Assessment method:

Weight of evidence approach, including standardised catch rates and Bayesian state-space implementation of the Schaefer surplus production model (BSM).

Main data inputs:

Key model structure & assumptions:

1. Standardised catch rates (using cede v. 0.04, Haddon, 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. 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 impact of recreational harvest ranging from 10-20% of reported commercial landings on BSM outputs.

Status Indicators - Limit & Target Reference Levels

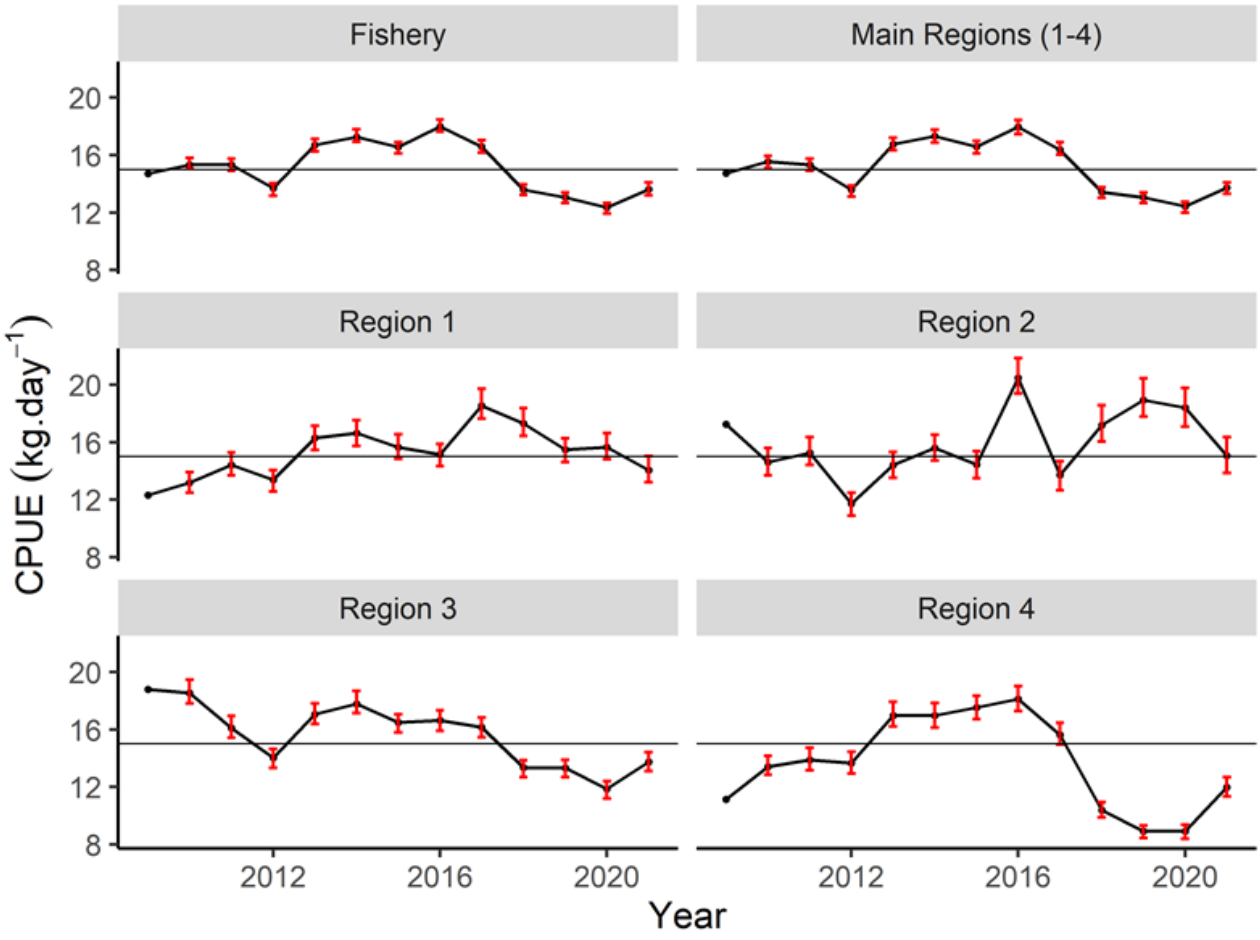
Biomass indicator or proxy	None specified in a formal harvest strategy. In the interim, for the purposes of this stock assessment a weight-of-evidence approach was used, which included: annual standardised catch rates from the fishery and four main regions;
Biomass Limit Reference Point	None specified in a formal harvest strategy. For the purpose of this stock assessment, 20% of the estimated unfished biomass was selected for the limit reference point (B_{lim}).
Biomass Target Reference Point	None specified in a formal harvest strategy. For the purpose of this stock assessment, 48% of the estimated unfished biomass was selected as the target reference point (B_{targ}).
Fishing mortality indicator or proxy	None specified in a formal harvest strategy. For the purposes of this stock assessment a weight-of-evidence approach was used, which included estimates of fishing mortality (F) and exploitation rate (F/F_{msy}) from BSM analyses.
Fishing mortality Limit Reference Point	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}) was selected.
Fishing Mortality Target Reference Point	None specified in a formal harvest strategy. For the purposes of this stock assessment the estimated harvest rate corresponding to 48% of estimated maximum biomass for the target reference point (H_{targ}) was selected.

Stock Assessment Results

Standardised commercial catch rates (in mean CPUE kg.day^{-1}) is likely to be the most reliable index of relative abundance for Giant Mud Crab. For recent data analysed as mean daily catch rates (available from 2009/10 to 2021/22, Figure4), catch rates (regions combined) remained

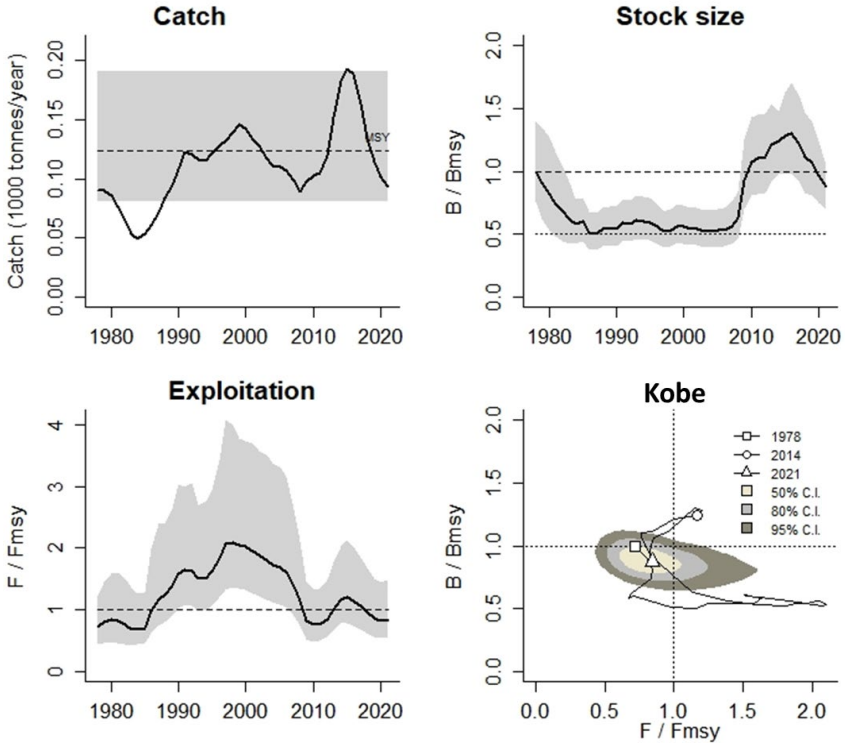
stable and average from 2013/14 to 2017/18, before declining from 2018/19 to 2020/21. Catch rates within the four main regions of the fishery are variable. For example, catch rates in Regions 3 and 4 declined consistently each year from 2018/19 to 2020/21, and were below average in 2021/22 (Figure 4). In contrast, catch rates in Regions 1 and 2 remained stable and above or approximately equal to long-term average from 2018/19 to 2021/22. The declines in catch rates from the fishery and main regions (1-4) are largely driven by declines in catch rates in Region 4 that accounted for 18 to 30% of reported landings from 2018/19 to 2021/22.

Figure 4. Standardised commercial catch rates with 95% confidence intervals from EGF, Regions 1-4 pooled and Regions (CPUE kg day^{-1} from daily records). The horizontal line represents the average catch rate (2009/10 – 2021/22).



For the BSM analyses Biomass *(B)* in the last year (1, 270 t, CI: 1, 010 -1, 510 t) is estimated to be lower than B_{msy} (1, 450 t, CI: 944 – 2, 440 t). Based on BSM analysis, estimates of fishing mortality (F) and exploitation rate (F/F_{msy}) in 2021/22 were 0.07 (CI: 0.06-0.09) and 0.85 (CI: 0.57-1.48), respectively (Figure 5).

Figure 5. BSM assessment results showing: annual catch trajectory (t) with estimated MSY; stock size (B/ B_{msy}) and exploitation rate (F/F_{msy}) trajectories (grey shading illustrates 90th percentile); and stock status trajectory from 1978/98 – 2021/22.



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}), standardised catch rates (regions combined) remained stable and above average from 2013/14 – 2017/18, although declining from 2018/19- 2020/21. For 2021/22, standardised catch rates from Regions 1 and 2 were ≥ long-term average, while catch rates from regions 3 and 4 were < long-term average. For BSM analyses current estimated mean *B* is above the B_{lim} level of 0.2B_0 for all analyses. 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	BSM analyses estimates B in the last year to be lower than B_{msy} (B/ B_{msy} = 0.874)
Fishing mortality in relation to Limit	Weight-of-evidence provided is sufficient to support an understanding that fishing mortality is at a level to avoid the stock being recruitment impaired.
Fishing mortality in relation to Target	Based on BSM analysis, estimates of fishing mortality (F) and exploitation rate (F/F_{msy}) in 2021/22 were 0.07 (CI: 0.06 - 0.09) and 0.85 (CI: 0.57 - 1.48), respectively.
Current SAFS stock status	Sustainable (Saunders *et al*., 2021)

Fishery interactions

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., 2022, Taylor et al., 2023).

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).

Qualifying Comments

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.

The impact of recent management changes (i.e. quota management) on catch rates has not been quantified. NSW estuaries are subject to periodic flooding events which have the potential to limit catches during large-scale floods, the most recent occurring in 2018 and 2022. The impact of factors other than changed population dynamics, including changed fishing practices, locations, catch reporting and catchability need to be investigated further.

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 analysis.

References

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Figure S1. Reported annual landings of Giant Mud Crab by sex from 2009/10 to 2021/22.

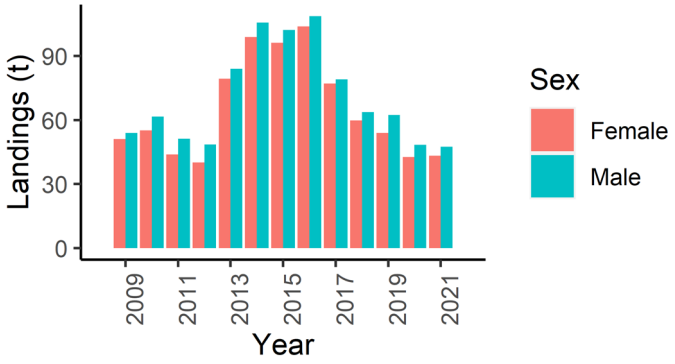

Figure S2. Reported landings from estuary general fishery regions from 1997/8 to 2021/22.

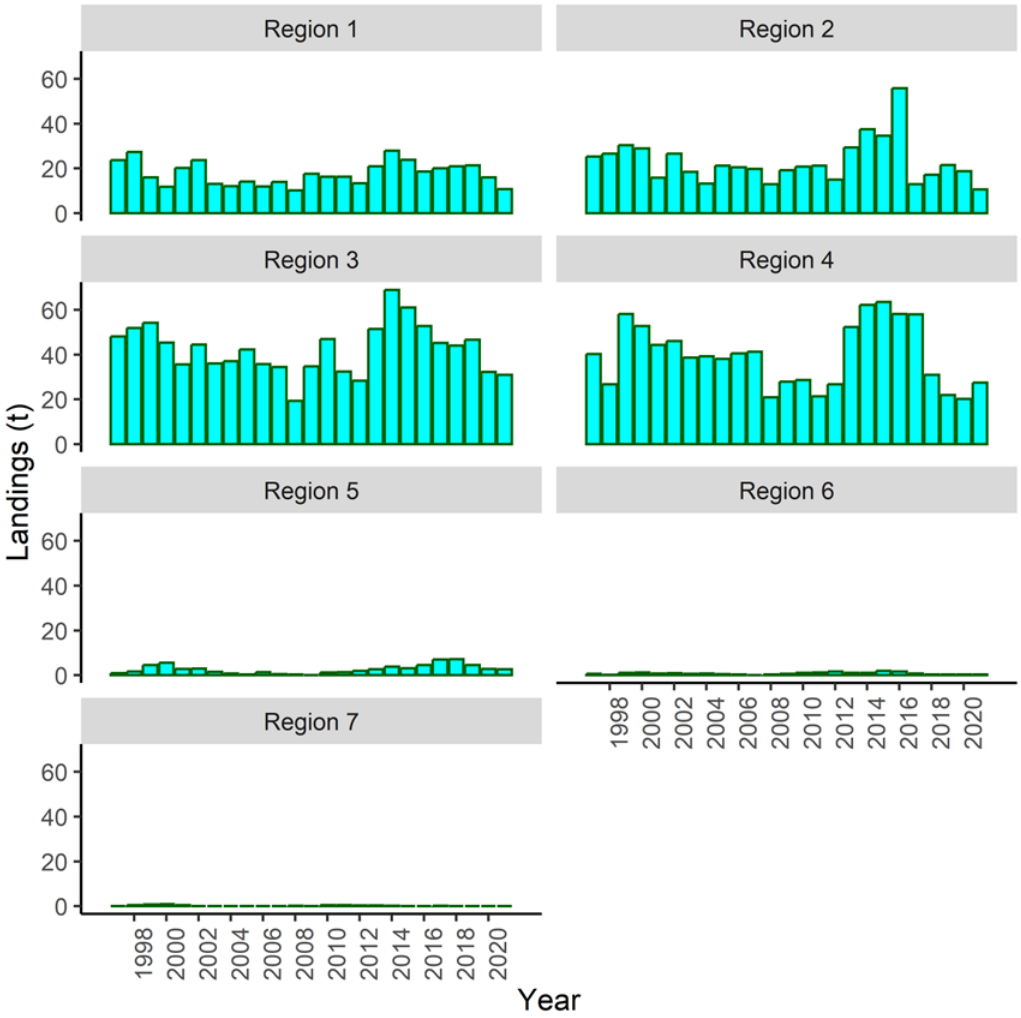

Figure S3. Reported annual landings (t) from main estuaries in estuary general fishery regions (R) 1 to 6.