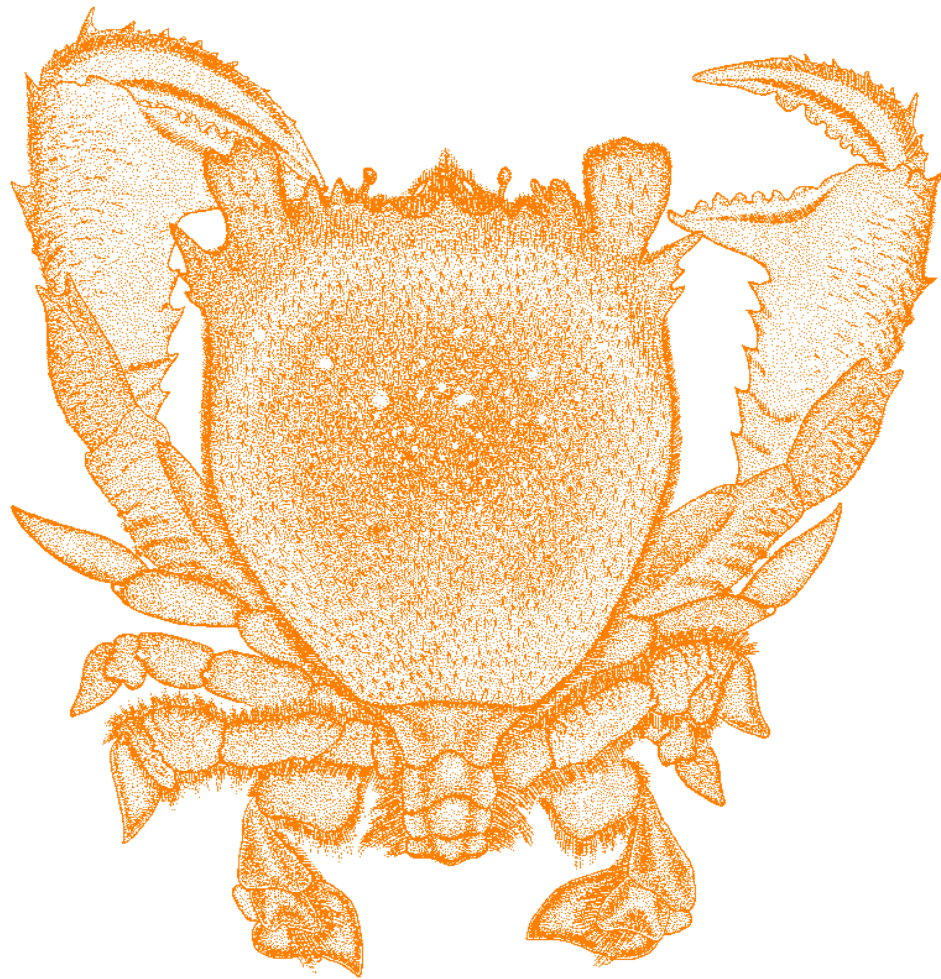


Queensland Spanner Crab Fishery

Commercial quota setting for June 2016 – May 2018



Species: *Ranina ranina*

This publication has been compiled by MJ Campbell and MF O'Neill of Agri-Science Queensland and JG McGilvray of Fisheries Queensland, Department of Agriculture and Fisheries.

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Summary

The Queensland (QLD) fishery for spanner crabs primarily lands live crab for export overseas, with gross landings valued around A\$5 million per year. Quota setting rules are used to assess and adjust total allowable harvest (quota) around an agreed target harvest of 1631 t and capped at a maximum of 2000 t. The quota varies based on catch rate indicators from the commercial fishery and a fishery-independent survey. Quota management applies only to 'Managed Area A' which includes waters between Rockhampton and the New South Wales (NSW) border.

This report has been prepared to inform Fisheries Queensland (Department of Agriculture and Fisheries) and stakeholders of catch trends and the estimated quota of spanner crabs in Managed Area A for the forthcoming annual quota periods (1 June 2016–31 May 2018). The quota calculations followed the methodology developed by the crab fishery Scientific Advisory Group (SAG) between November 2007 and March 2008.

The QLD total reported spanner crab harvest was 1170 t for the 2015 calendar year. In 2015, a total of 55 vessels were active in the QLD fishery, down from 262 vessels at the fishery's peak activity in 1994. Recent spanner crab harvests from NSW waters average about 125 t per year, but fell to 80 t in 2014–2015.

The spanner crab Managed Area A commercial standardised catch rate averaged 0.818 kg per net-lift in 2015, 22.5% below the target level of 1.043. Compared to 2014, mean catch rates in 2015 were marginally improved south of Fraser Island.

The NSW–QLD survey catch rate in 2015 was 20.541 crabs per ground-line, 33% above the target level of 13.972. This represented an increase in survey catch rates of about four crabs per ground-line, compared to the 2014 survey.

The QLD spanner crab total allowable harvest (quota) was set at 1923 t in the 2012-13 and 2013-14 fishing years, 1777 t in 2014-15 and 1631 t in 2015-16. The results from the current analysis rules indicate that the quota for the next two fishing years be retained at the base quota of 1631 t.

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Introduction

The Australian spanner crab fishery operates across the jurisdictional waters of QLD and NSW between ~22 and 30°S. It is the largest spanner crab fishery in the world, with annual gross landings up to ~2000 t taken primarily from QLD waters (O'Neill et al., 2010). Spanner crabs are large, growing to about 15 cm rostral carapace length (~0.75 kg), generally mature above 7 cm, and live in oceanic waters from shallow intertidal depths to at least 100 m on sandy substrates. They are caught by entangling their legs on tightly strung 32 mm mesh over a flat square or rectangular metal frame enclosing an area of about 1 m². Spanner crabs grow more slowly than other QLD crab species, although estimates of longevity have varied with scientific study. Maximum longevity was estimated up to ~15 years with females requiring ~6 years and males ~4 years to reach minimum legal size of 10 cm rostral carapace length (Brown et al., 1999; Kirkwood et al., 2005).

In QLD, commercial fishing for spanner crabs is managed under licences marked with a C2 or C3 fishery symbol (Queensland Government, 2008). The Managed Area A (C2 fishery symbol, Campbell et al., 2016) is fully developed and accounts for over 95% of the total harvest of spanner crabs in QLD. The commercial quota harvest limit (total allowable commercial catch – TACC) for Managed Area A is reviewed every two years.

As of 18 January 2016, 223 C2 symbols were available; four more than in 2015. Individual quota holdings can be traded between licence symbols. For the current 2015-16 fishing season in Managed Area A, there are 62 quota account holders and 10 clients leasing quota. The remaining licences holding a C2 symbol are unable to fish for spanner crabs as they do not currently hold quota. The number of spanner crab dilly nets per licence is limited to 45 in Managed Area A. However, as of November 2015, 37 general fisheries permits (GFP) were active allowing vessels to use up to 120 dilly nets depending on the number of crew on-board.

The annual TACC for Managed Area A is set using an empirical (data-based) management procedure (Dichmont and Brown, 2010; O'Neill et al., 2010). The management procedure has limited QLD landings to less than 2000 t since the introduction of output quota control in 2002. The current management procedure for spanner crab, including harvest control rules, operate around an agreed base quota of 1631 t, with a maximum quota capped at 2000 t and catch rate abundance indicators compared against target reference points (O'Neill et al., 2010). For detail on last year's quota setting or data see Campbell et al. (2016).

This report has been prepared to inform Fisheries Queensland (Department of Agriculture and Fisheries) and stakeholders of the estimated quota of spanner crabs in Managed Area A for June 2016 to May 2018. The determination was made applying the methodology developed by the crab fishery Scientific Advisory Group (SAG) between November 2007 and March 2008. Application of the management decision rules (Appendix 1) indicate that the commercial quota of spanner crab should be set to the base TACC of 1631 t.

Methods

The commercial data presented herein were extracted from the Fisheries Queensland DME database on 11 January 2016, representing spanner crab harvests from January 1988 to 31 December 2015. All current fishery-independent survey data from NSW and QLD were provided mid-December 2015. For detail on the data definitions and assumptions, see Campbell et al. (2016).

Spanner 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 package GenStat (VSN International, 2013). The importance of individual model terms was assessed formally using Wald (Chi-square) statistics by dropping individual terms from the full model (VSN International, 2013).

Commercial catch rates of spanner crabs were analysed assuming normally distributed errors on a cube root scale (McCullagh and Nelder, 1989). The model response variable (η) consisted of the cube root of the daily catch ($\text{kg}^{1/3}$) from each vessel. Explanatory model terms included the three-way interaction between fishing years, regions and months, as well as the main effects of individual vessels, their cube root transformed fishing effort (the number of net-lifts, which was a function of the number of ground-lines used, nets per ground-line and ground-line lifts per day), the spatial resolution of catches based on 30×30 min latitude and longitude grids, the lunar cycle (O'Neill and Leigh, 2007) and the interaction of GFP licences with fishing effort to allow for different fishing dynamics. No additional fishing power data were available since 2007 and to be consistent with Brown (2012), the 2007 value was used for subsequent years.

Commercial catch rates were predicted from the model 'year' term using GenStat procedure 'predict', which provided the annual abundance estimates standardised to the mean number of net-lifts^{1/3} (~ median). Predicted catch rates from the cube root model were adjusted using a bias-corrected back-transformation (bcbt) of $\mu^3 + 3\mu\sigma^2$. The adjusted predictions (bcbt) were rescaled in order to compare 2014–2015 catch rates to the base 2000–2007 fixed reference catch rate of 1.043 kg per net-lift.

Survey catches of spanner crabs across the years exhibited a significant component of zero values (~ 23%). As no single statistical distribution can accommodate this inflated zero class, catches were standardised through a two-component approach, combining mean predictions from binomial regression of zero/non-zero catch and general linear regression on the conditionally distributed log-transformed non-zero catches (McCullagh and Nelder, 1989; Myers and Pepin, 1990; Mayer et al., 2005). The first component relates to the binary response of zero or non-zero catch per ground-line, modelled using a logistic transformation with a linear function of the factor variable survey-area, log-transformation of total net hours per ground-line, and factor variable year. The second component was for just those catches where the number of crabs caught was not zero. The model response variable (η) consisted of the logarithm of number of crabs caught per ground-line. Explanatory model terms were the same as in the binary analysis.

Predicted survey catch rates from the log-normal model were adjusted using a common bias-corrected back-transformation of adding half the model variance i.e. $e^{\left(\mu + \frac{\sigma^2}{2}\right)}$. These catch rates were then multiplied by the binary predicted proportions for non-zero catch, to predict the overall standardised average number of spanner crabs per ground-line equivalent to the median net-hours of

fishing. The predictions were standardised according to the base 2000–2007 fixed reference catch rate of 13.972 crabs per ground-line.

The management procedure followed a process of a baseline quota and performance targets for standardised catch rates with range intervals. The base quota (Q_{base}) and target catch rates were set by the SAG and fixed at their annual averages between 2000 and 2007. Upper and lower intervals of $\pm 10\%$ were set on target catch rates. The stock performance indicators are the average fishery and survey standardised catch rates in the most recent two completed calendar years. Standardised catch rates from the fishery and the survey were compared to the performance targets equally. The spanner crab quota was calculated from the base quota ($Q_{base} = 1631$ t) and was made no larger than the maximum tonnage allowed ($Q_{max} = 2000$ t). New quota was compared with the tonnage set previously: if the new quota was within 5% of the previous quota, then the quota remained unchanged. Quota was calculated according to the equation:

$$Q_{t+} = \min \left[\begin{cases} Q_t & , \text{ if } (0.95Q_t \leq \lambda Q_{base} \leq 1.05Q_t) \\ \lambda Q_{base} & , \text{ otherwise} \end{cases}, Q_{max} \right],$$

where Q is the quota tonnage for setting in years $t+$, and λ was the pooled index. For an extended plain English version of the quota rules see Appendix 1.

Table 1: Decision matrix for setting λ in the quota calculation, with subscripts u and l indicating upper and lower $\pm 10\%$ catch-rate thresholds and θ an average ratio of fishery and survey catch rates from the last two years divided by their target.

Mean catch rates (\bar{c})	Commercial fishery (f)		
	$\bar{c}_f \leq \bar{c}_{f,target,l}$	$\bar{c}_{f,target,l} < \bar{c}_f < \bar{c}_{f,target,u}$	$\bar{c}_f \geq \bar{c}_{f,target,u}$
Survey (s)			
$\bar{c}_s \geq \bar{c}_{s,target,u}$	$\left[\begin{array}{ccc} 1 & 1 & \theta_{halfup} \\ 1 \text{ or } \theta & 1 & 1 \\ \theta \text{ or } 0 & 1 \text{ or } \theta & 1 \end{array} \right]$		
$\bar{c}_{s,target,l} < \bar{c}_s < \bar{c}_{s,target,u}$			
$\bar{c}_s \leq \bar{c}_{s,target,l}$			

Matrix cell row 2, column 1: if $\bar{c}_s < \bar{c}_{s,target}$, then $\lambda = \theta$, else $\lambda = 1$.

Matrix cell row 3, column 1: if $\theta \leq 0.5$, then $\lambda = 0$, else $\lambda = \theta$.

Matrix cell row 3, column 2: if $\bar{c}_f < \bar{c}_{f,target}$, then $\lambda = \theta$, else $\lambda = 1$.

Matrix cell row 1, column 3: $\lambda = \theta_{halfup} = (\theta - 1)/2 + 1$,

$$\theta = \frac{\bar{c}_f / \bar{c}_{f,target} + \bar{c}_s / \bar{c}_{s,target}}{2}$$

Quota results and discussion

Analysis of the commercial data indicated that the two year 2014–2015 average (0.780 kg per net-lift) was $\sim 26\%$ below the target indicator of 1.043 kg net-lift⁻¹ (Table 2). Additionally, the average catch rate from the 2014 and 2015 surveys was 18.616 crabs per ground-line, 33% above the target level of 13.972.

The Pooled Index (the arithmetic mean of the two commercial and survey indices) was 0.991. A summary of the reference points and indicators follows:

- **Current quota: 1631 tonnes.**
- **Base quota (Q_{base}):** The value of this fixed base for QLD is **1631 tonnes.**

- Base Commercial Fishery Catch Rate ($\bar{c}_{f,target}$): The value of this reference point is **1.043 kg per net-lift**.
- Base Survey Catch Rate ($\bar{c}_{s,target}$): The value of this reference point is **13.9721 crabs per ground-line**.
- Commercial Index. This stock performance indicator (**0.748**) was derived as the average of the 2014 and 2015 adjusted mean catches expressed as a proportion of the base commercial fishery catch rate.
- Survey Index. This stock performance indicator (**1.332**) was expressed as a proportion of the base survey catch rate.
- Pooled Index. This overall stock performance indicator (**1.040**) was calculated as the arithmetic mean of the commercial and survey Indices.

Table 2: The adjusted mean (modelled) annual commercial and survey catch rates and stock performance statistics for setting commercial quota.

Year	Commercial	Survey
2014	0.742	16.691
2015	0.818	20.541
Average 2014–2015	0.780	18.616
Base catch rates (2000-	1.043	13.972
Stock Index	0.748	1.332
Pooled Index	1.040	

By referencing the stock indicators against the management procedure rules (see Appendix 1) and Table 1, the following applies:

- Indicator result – Rule 5, Table 1, cell row 1 and column 1, the quota is equal to the Base TACC of 1631 t.

The indicator result, Table 1: cell row 1 and column 1, corresponded to inconsistent indices: the commercial data indicated catch rates were below target and the survey data was still above target. In this case the management procedure defaulted to the base harvest 1631 t.

At the industry meeting convened at Mooloolaba in April 2015, some fishers raised concerns over localised depletions, the prevalence of small crabs within the catch and the poor performance of the fishery when compared with previous years. The signals in the commercial data on face value are concerning, with falling catch and catch rate of legal sized crab, changes in spatial patterns of fishing, reduced participation and increased permits to fish more apparatus. When combined with the assessment risks of hyperstability and under-representing fishing power in commercial catch rates, re-examination of the operational objectives and reference points for the fishery may be warranted (Decision Rule 6, Appendix 1).

Some matters of note with the current assessment framework (or method) are:

- Given the fishery and the economics of fishing have changed since 2006/07 adjustment to quota baselines (\uparrow catch rate targets $\bar{c}_{f,target}$ and $\bar{c}_{s,target}$, and $\downarrow Q_{base}$) may be required to improve the certainty surrounding values of sustainable and profitable harvest. For evaluating profitable fishing, it is important to consider a base quota of less than average harvest (~ consistent with active fleet size) and updating baseline catch rates towards targets that are higher than average (O'Neill et al., 2010).

- The longer survey time series has revealed the 13.972 crabs ground-line-1 reference target catch rate (averaged from the 2000–2007 years) was based on significant low point in 2002 (Figure 5). The 2002 year was also a low point in commercial catch rates (Figure 2a). These low points may incorrectly cause setting higher quota and/or inconsistency between commercial and survey indices. The standardised time series of catch rates, including all years, now averages 15.379 crabs per survey-ground-line² and 1.026 crabs per commercial-net-lift.
- The use of Authority Chain Number (ACN) as a ‘boat’ identifying term in the analysis of commercial catch rates has become problematic. The high number of logbook ACNs has caused some model aliasing when analysing interactions of boats with fishing regions and months. For analysing the three-way interaction (strata combination of ‘boat x region x month’), the ratio of the number of data (boat days) against the number of model parameters per strata combination is reduced. This leads to difficulties when predicting commercial spanner crab catch rates in each region. The number of boats (ACNs) in the analysis now totals about 253. The computer coding (ACNs) for identifying different spanner crab boats needs to be checked against the licencing table; including information on different skippers.
- New additional fishing power data are required from 2007 onwards. The data chronicles the history of change in fishing vessels, skippers and technologies (O’Neill et al., 2010). Ideally, the collection of updated data would follow the face-to-face survey methodology of O’Neill and Leigh (2006). This would first involve developing an updated check list on relevant fishing technologies. This work would proceed after the data checking of ACNs.

The ACN problem was overcome in this year’s commercial analysis by simplifying the model interaction to ‘region x month’ and adding boat to the model as a main effect only. However, such issues can also be overcome by employing mixed models and adding ‘boat’ as a random term in such a model. It is recommended that the model methods (model type and terms) used to predict commercial catch rates be reviewed, in consultation with a scientific working group, to ensure the most appropriate outputs are used.

If a change to the quota process is advanced under Decision Rule 6 (Appendix 1), then clear reasons on the need to shift the baselines to more representative and profitable values must be documented by Fisheries Queensland and the commercial spanner crab industry. A process to review elements of the management procedure and operational objectives is required to ensure future quotas improve the commercial stock and particularly the abundance of larger crabs.

Acknowledgements

Nadia Engstrom and LTMP staff provided the commercial logbook and fishery independent survey data and we thank them for their patience and thoroughness. We also thank Daniel Johnson from NSW Primary Industries who provided information on the NSW commercial spanner crab catch and the fishery independent survey.

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Appendix 1: Management procedure

Prior to 28 February of each year in which the biennial quota cycle commences, the Chief Executive will assess the status of the spanner crab stock and re-set the Annual Quota for each of the two forthcoming years in Managed Area A (Regions 2-6).

This assessment will be based on an analysis, using procedures set out in Methods above, of changes in relative stock abundance as represented by the fishery-dependent and fishery-independent catch and effort data recorded by the Chief Executive. This set of procedures is referred to as the Scientific Method.

Notwithstanding the biennial nature of the Quota-setting cycle, the Chief Executive will each year conduct an assessment of the fishery (as above), and in the event of evidence of a sudden and catastrophic collapse of the stock will institute immediate remedial action using emergency powers provided under the Act.

In determining the Annual Quota, the Chief Executive will apply the following Decision Rules:

1. If the Pooled Index is 0.5 (–50%) or less, the Chief Executive must declare the Annual Quota to be nil; or
2. If the Commercial Index and the Survey Index are both greater than 1.1 (+10%), the Chief Executive must declare the Annual Quota to be equal to the BaseTAC increased by half the amount of the Pooled Index, with the provisos (i) that if the new value lies within $\pm 5\%$ of the current Annual Quota, then the new Annual Quota will be set equal to the current Annual Quota, and (ii) that, notwithstanding any of the above, the new Annual Quota will not exceed 2,000 t; or
3. If one Index is less than 0.9 (–10%) and the other is between 1 and 0.9 (0 and –10%), the Chief Executive must declare the Annual Quota to be equal to the BaseTAC reduced by the full amount of the absolute (unsigned) Pooled Index, with the proviso that if the new value lies within $\pm 5\%$ of the current Annual Quota, then the new Annual Quota will be set equal to the current Annual Quota; or
4. If the Commercial and Survey Indices are both less than 0.9 (–10%), the Chief Executive must declare the Annual Quota to be equal to the BaseTAC reduced by the full amount of the absolute (unsigned) Pooled Index, with the proviso that if the new value lies within $\pm 5\%$ of the current Annual Quota, then the new Annual Quota will be set equal to the current Annual Quota; or
5. The Chief Executive must declare the Annual Quota to be equal to the BaseTAC.
6. If and when any new information becomes available indicating that the assessment and quota-setting arrangements are not consistent with the sustainable management of the fishery, the Chief Executive must review the Scientific Method and Decision Rules and, if appropriate, adjust the reference points.

Appendix 2: Additional statistics

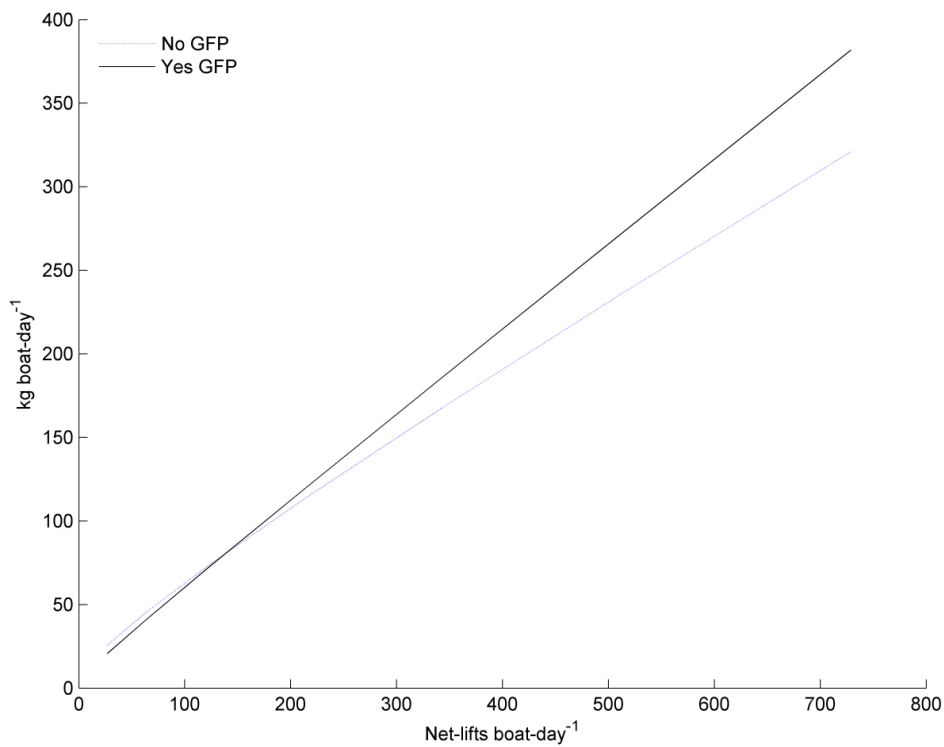


Figure 1: Plot showing the GFP vessel effect of net-lifts on daily harvest boat-day⁻¹. Note that the typical number of net-lifts boat-day⁻¹ for non GFP ranged 150–350 and 250–450 for GFP, with the full range illustrated in Figure 3.

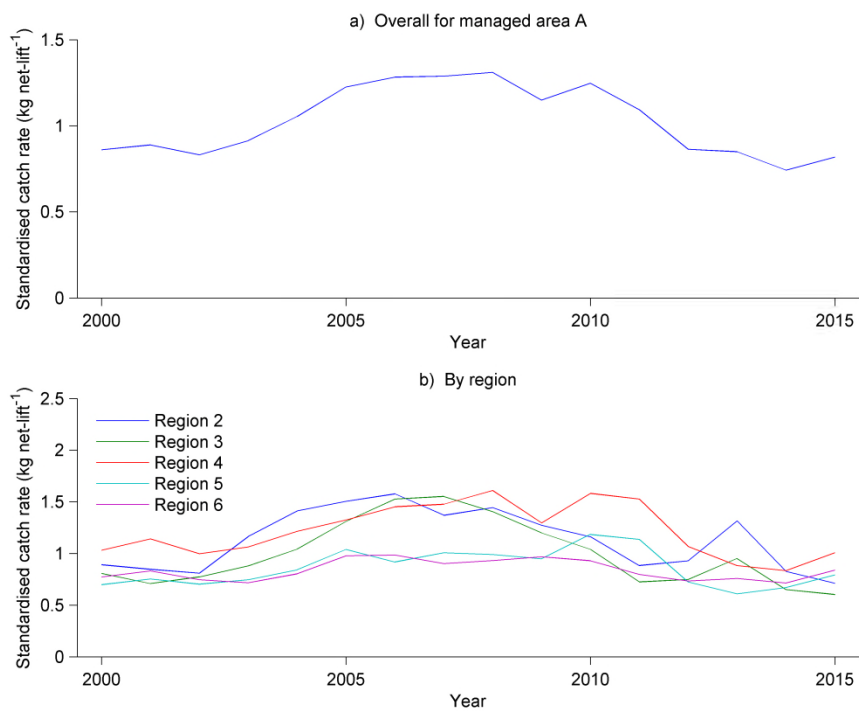


Figure 2: Standardised annual commercial catch rates of spanner crabs for a) Managed Area A and b) by region.

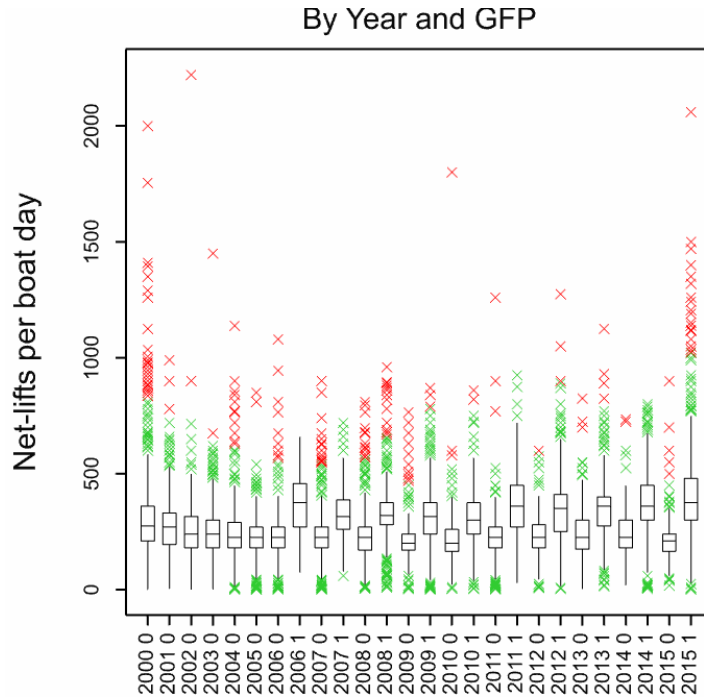


Figure 3: Boxplot of the variation in net-lifts boat-day-1 by year and general fisheries permit (GFP 0 = no and GFP 1 = yes). The box spans the interquartile range of the data, so that the middle 50% of the data lie within the box, with a horizontal line indicating the median. The vertical lines (whiskers) extend only to the most extreme data values which are at a distance of 1.5 times the interquartile range. Outlying data are plotted with circle and cross symbols.

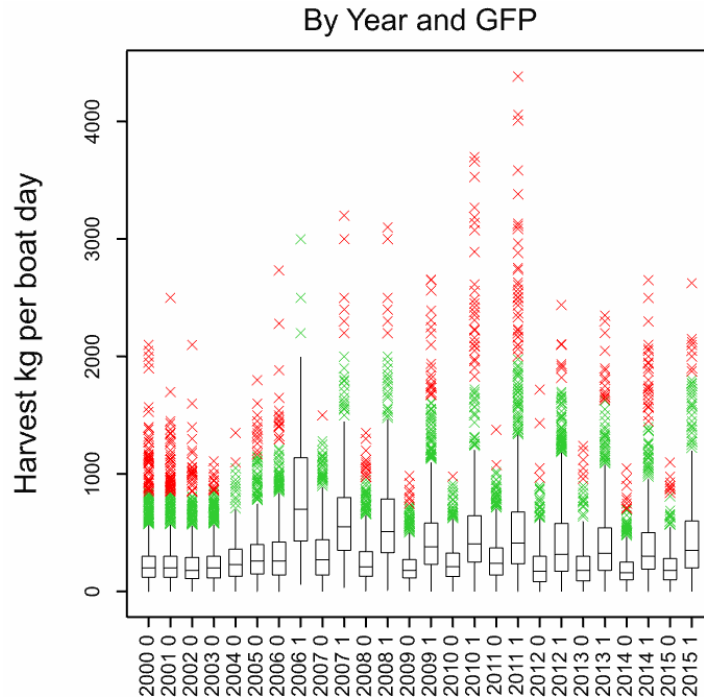


Figure 4: Boxplot of the variation in harvest kg boat-day-1 by year and general fisheries permit (GFP 0 = no and GFP 1 = yes). The box spans the interquartile range of the data, so that the middle 50% of the data lie within the box, with a horizontal line indicating the median. The vertical lines (whiskers) extend only to the most extreme data values which are at a distance of 1.5 times the interquartile range. Outlying data are plotted with circle and cross symbols.

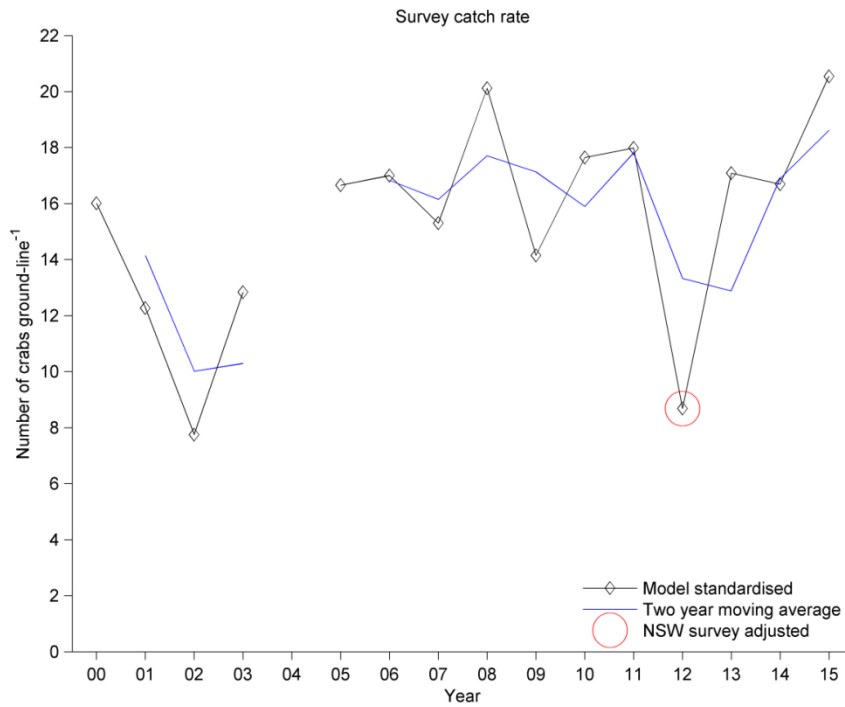


Figure 5: Standardised average catch of spanner crabs per ground-line set and average soak time ~ 53 minutes. The blue line is the two year moving average used in quota calculation. Note: the 2012 mean was based on NSW survey sites only (red circle). The 2012 mean was standardised upwards by the GLM adjusting for the missing 2012 QLD survey locations; up from 7.15 crabs ground-line-1 surveyed in NSW (Figure 6).

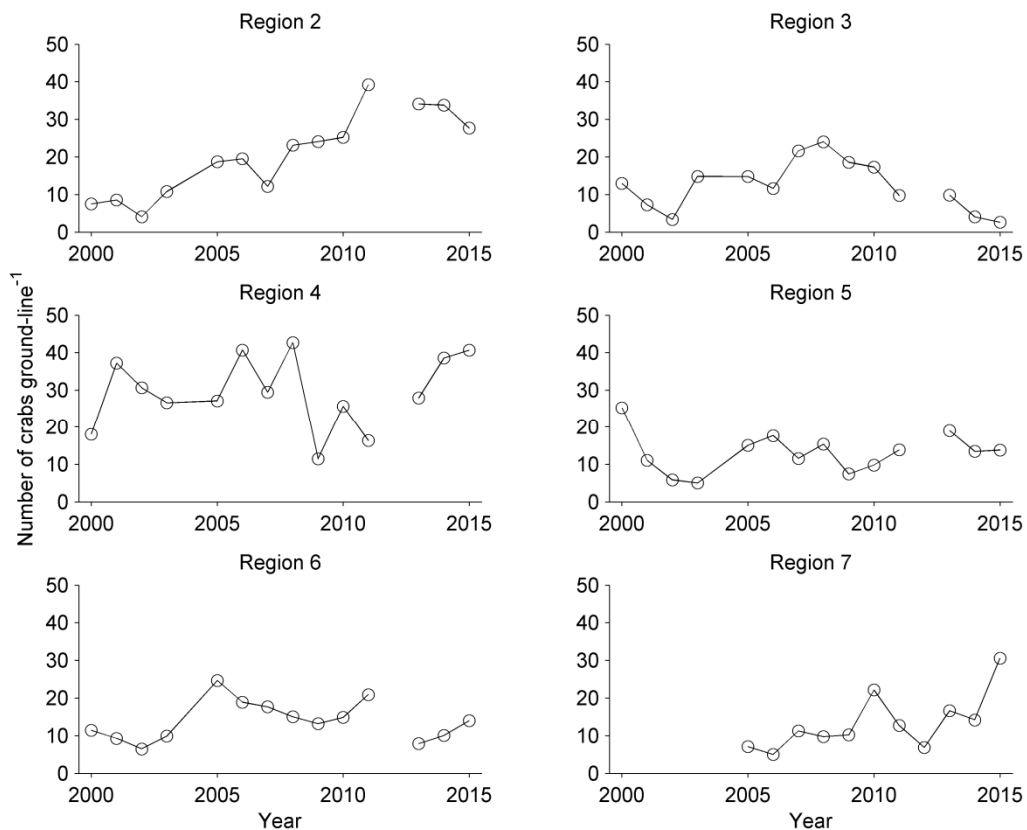


Figure 6: Nominal average survey catches of spanner crabs per ground-line by region.

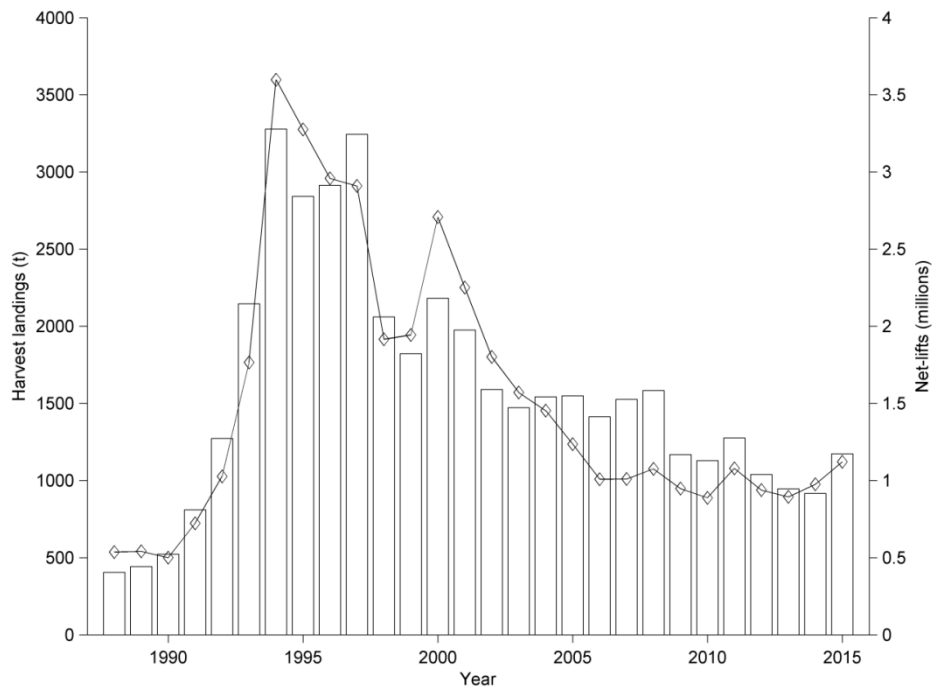


Figure 7: Annual commercial spanner crab harvest landings (t), overlaid with annual fishing effort (million net-lifts) from all QLD waters.

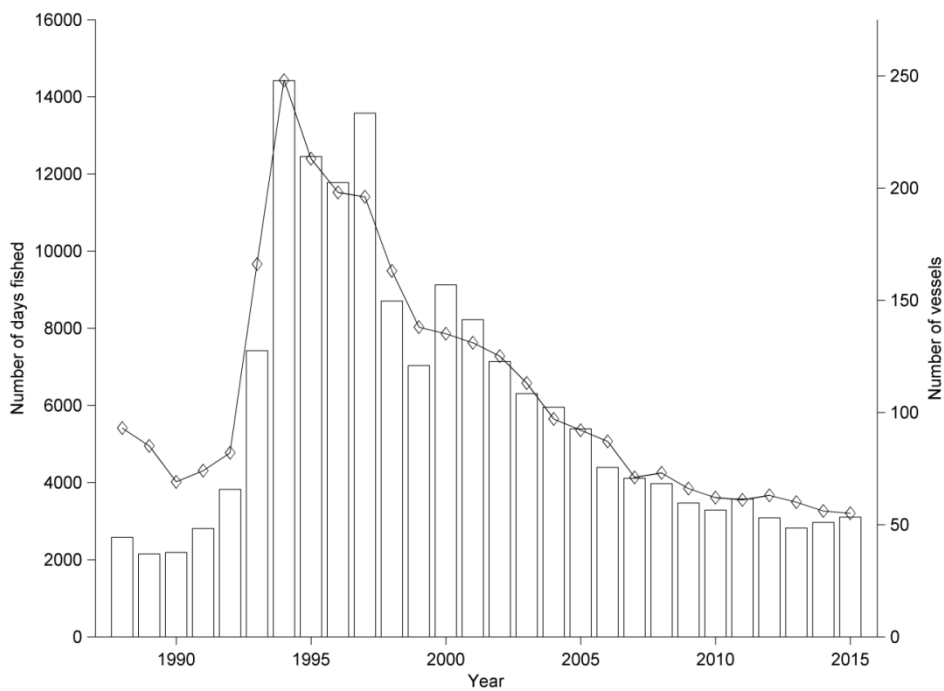


Figure 8: Annual number of commercial days fished for spanner crabs, overlaid with annual vessel numbers from all QLD waters.

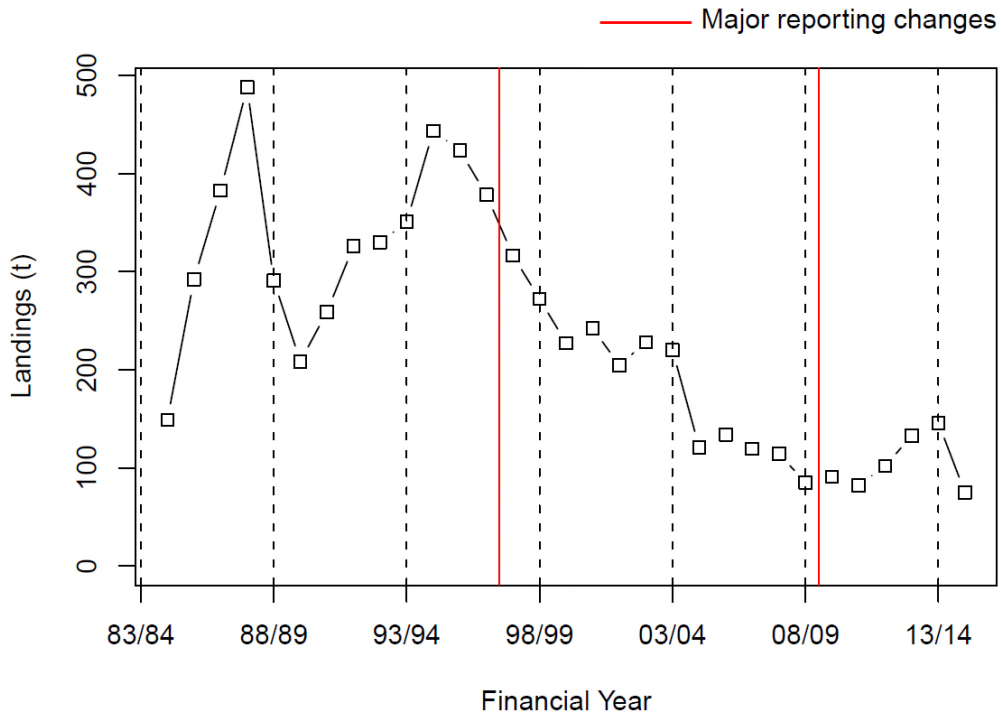


Figure 9: Spanner crab harvest landings (t) from NSW waters as a function of financial year.

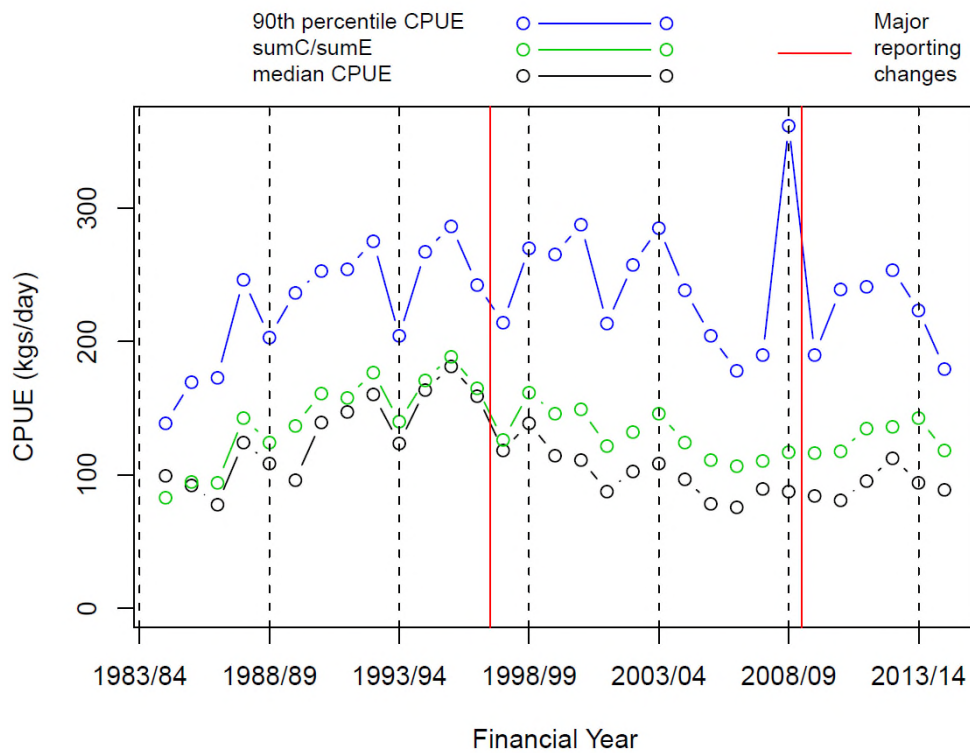


Figure 10: Spanner crab CPUE (kg boat-day-1) from NSW waters as a function of financial year.