Standardised catch rates for Queensland Moreton Bay bugs (*Thenus* spp.)

2020

Queensland Government

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Summary

Moreton Bay bugs are taken predominantly by two fleets in Queensland: one fleet north of 22° S trawling for prawns and one fleet south of 22° S trawling for scallops. Overall, the catch rate increased between 2002 and 2013 and then declined before stabilising in recent years (Figure 1). The increase in catch rate in the early 2000s is likely due to the targeting of Moreton Bay bugs as the market value for bugs increased. These standardised catch rates will inform fisheries management and the status determination for the Status of Australian of Fish Stocks.

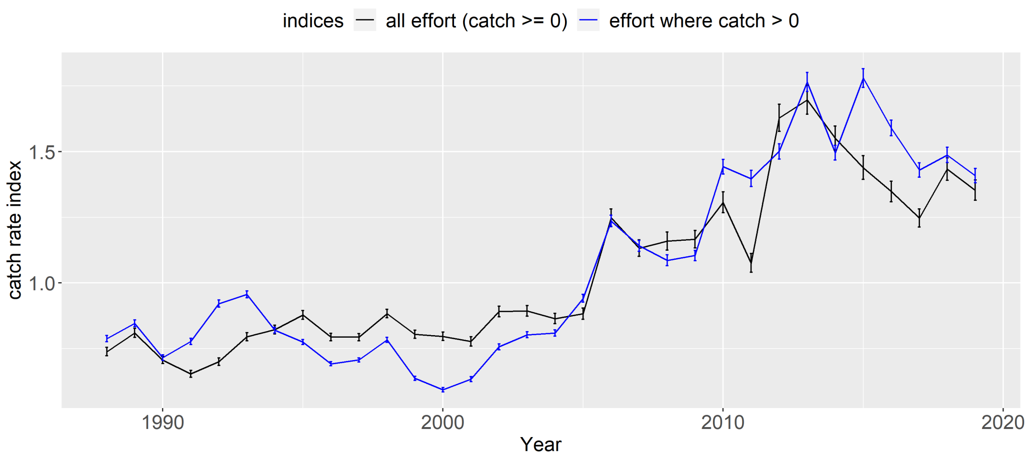

Figure 1: Annual standardised catch rates and standard errors for Moreton Bay bug from 1988 to 2019

Acknowledgements

The project was supported by the Queensland Department of Agriculture and Fisheries. Support was provided by the project team which consisted of the following scientists and managers: Michael O'Neill, Tony Courtney, Ashley Lawson, Andrew Prosser, Darren Roy, Sam Williams, Eddie Jebreen and Sue Helmke. Thanks to Matthew Macmillan for scientific advice and discussions on the spatial distribution of bugs and to Samara French for contributions to the R code. Additional thanks go to the data team: Ashley Lawson, and Prasadini Salgdo for their advice and supplying the Queensland commercial harvest data.

Finally, thanks to Alise Fox, Sue Helmke, Eddie Jebreen and the project team for reviewing and providing comments on parts of the report.

1 Introduction

'Moreton Bay bugs' is a collective term for two species: reef bug (*Thenus australiens*) and mud bug (*T. parindicus*). Moreton Bay bugs are a valuable product of Queensland's prawn and scallop trawl fisheries and account for about 80% of bug landings and value in Queensland (Courtney et al. 2002). Moreton Bay bugs are taken mainly by trawl along the Queensland coast north of about 25° S and in depths less than 80 m.

Within the Moreton Bay bug fishery there are two separate fleets. The fleet north of 22° S targets prawns (mainly redspot king and tiger) and the fleet south of 22° S targets scallops, although there may have been a shift toward bugs in the last decade. These fleet specific activities may give rise to differences in gears used between the fleets and/or differences in fishing behaviour.

The last assessment of Queensland Moreton Bay bug was completed in 2002 (with data to 2001, Courtney et al. (2002)) and was based on a yield-per-recruit analysis. Results reported no evidence of a significant decline in catch rate, over the five years prior to 2001, in the major areas of the fishery near Townsville and Gladstone. There were reports of a decline in landings, however this appears largely due to reductions in fishing effort (Courtney et al. 2002). Management changes (Table 1.1) may also contribute to differences in fleet behaviour which may affect catch rates.

Table 1.1: Management changes applied to East Coast Trawl fishery and stocks of Moreton Bay bugs in Queensland waters

Year	Fisheries Management, Regulations and Operations
1980	1400 licence vessels
1988	Compulsory commercial catch logbook reporting of catch commenced
1999	Introduction of East Coast Trawl Management Plan Reduction of licence operators from 1400 to 800 vessels
2000	Introduction of southern trawl closure from 20 September to 1 November
2001	Revised plan: buy back and effort management system, effort unit trading system Introduction of an effort management system based on effort nights
2002–2003	Increase in average boat size due to smaller boats (i.e 10–40 hull units) leaving the fishery as a result of licences being bought out by the government buyback scheme
2004	Reduction of licence operators to 527 vessels Compulsory commercial logbook reporting of gear commenced Vessels begin use of computer mapping and GPS Use of bycatch reduction devices and turtle exclusion devices
2010	Berried female Moreton Bay bugs can be retained

This document presents results for annual harvest and catch rate standardisation using data to 2019. Results presented are intended to inform fisheries management and status determination for the Status of Australian Fish Stocks (fish.gov.au).

2 Methods

Data included in this report were used to estimate catch rates, and generate total annual harvests. Daily harvest (kg) and authority chain numbers for 30’ logbook grids were obtained for trawl fishing between 1988 and 2019 calendar years (CFISH logbook catch data), collected by Fisheries Queensland. Lunar data was based on O’Neill et al. (2006) and consisted of a continuous daily luminous scale of 0 (new moon) to 1 (full moon).

The following criteria were applied to the logbook data to filter catch and effort data specific to Moreton Bay bugs:

- grids were selected where bugs are likely to be caught based on TrackMapper data (30 x 30 minute grids) and less than 80 m depth (Appendix A, Figure A.1)
- all catch of bugs north of 22° S were classified as as Moreton Bay bug
- all catch of ‘Bugs - Moreton Bay’ and ‘Bugs - unspecified’ south of 22° S were classified as Moreton Bay bug
- all bugs in the following grids are classified as Moreton Bay bug: S29, T29, S30, T30, U31, U32, V32, W35

The data set was further filtered to include a core set of grids and vessels. Catches were aggregated over all years and the grids with 90% of the total catch were selected. Following from that, a set of core vessels were selected that had fished for at least 2 years or more. The data were subdivided into two fleets: north of 22° S and and south of 22° S.

A known property of this fishery is the incidence of ‘NA’ in catches and effort, and therefore the data were treated in two ways resulting in two datasets for analysis:

1. effort where catch ≥ 0: all records with ‘NA’ in catches for Moreton Bay bug were replaced with 0.1 kg, so that it could be included in the analysis and not influence the catch rate trends.
2. effort where catch > 0: all records with zero or NA in catches for Moreton Bay bug were removed and all records with zero or NA in effort were also removed.

Standardised catch rates were analysed for each dataset using a generalized linear model (GLM) with an identity link using R software (R Core Team, 2019):

$$\text{log(catch)}\sim\text{year+vessels+log(hours)+month+grid+lunar}$$

The catch rate indices are based on the year effect, for each year, which reflects changes in annual abundance. In a GLM model with an identity link, the annual indices are the coefficients for the year term and scaled to the mean as follows:

$$\text{index = exp(coefficient - mean(coefficient))}$$

Therefore indices are the year coefficients, and the year coefficients change with the addition of each new term in the model. Each of the six terms were fitted sequentially to the catch effort data and the results presented as step plots. The influence of each term additional to the ‘year’ term was presented as influence plots.

3 Results and discussion

After filtering on species and area of fishing grounds for Moreton Bay bug, 398 grids remained and these were used for estimating annual catches (Figure 3.1). Details on the catches remaining, after filtering criteria were applied, can be found in the Appendix B (Figure B.1). Catches peaked between 1995 and 1998 and were proportionally higher in the northern fleet (Figure 3.1). The catches declined over the subsequent three year period and remained between 400 and 500 tonnes, between 2002 and 2010. Since 2013, catches have remained stable and over both fleets combined were generally between 500 and 600 tonnes. Over the history of recorded catches the northern fleet had a higher proportion of catches prior to 2005. The catch distribution changed slightly from 2005 onward, with the southern fleet having a slightly higher proportion of catches for the majority of the years compared to the northern fleet. This could be a reflection of the targeting behaviour of the southern fleet away from scallops and toward Moreton Bay bugs.

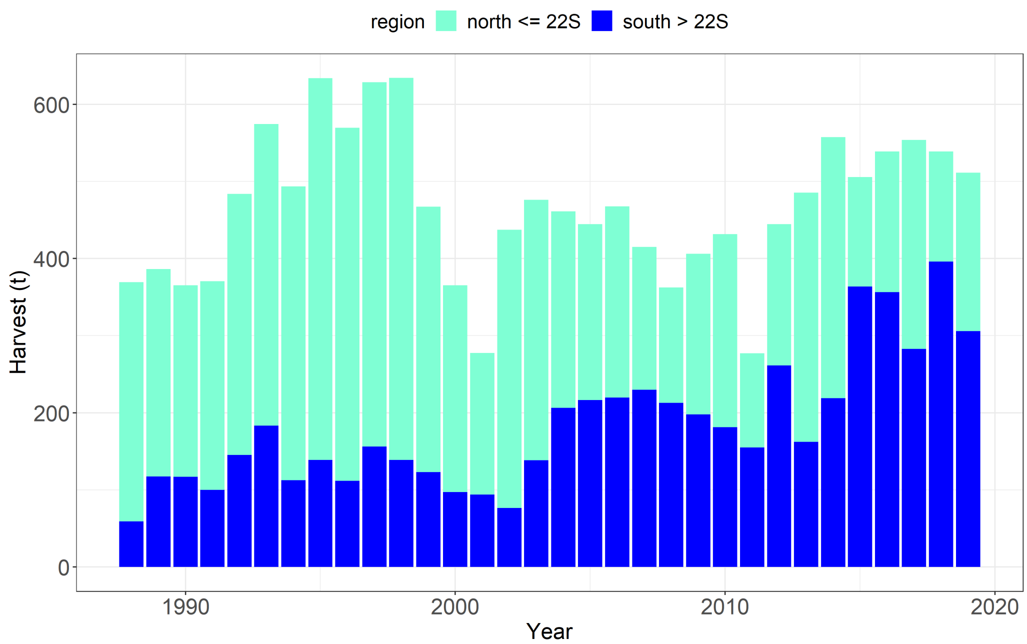

Figure 3.1: Annual Moreton Bay bug harvest from the southern and northern fleets from 1988 to 2019

Upon filtering on the highest 90% of landings, the highest landings occurred in 35 logbook grids (30’ x 30’ grids), for the period 1988–2019. The remaining 300+ grids accounted for about 10% of the catch. In the northern fleet, 21 grids had the highest catch and in the southern fleet, 14 grids had the highest catch. These grids were used to estimate catch rates for the fishery as a whole and for each fleet. Following the filtering and data selection process, only a small reduction in catches resulted, indicating that the resulting dataset remains representative of the fishery (Figure B.1).

The standardised and non-standardised catch rates are presented in Figure 3.2 for the fishery as a whole with the southern and northern fleet combined. Results are presented for two sets of data: catches with all effort (effort where catches were greater than or equal to zero) and effort where Moreton Bay bugs catches were greater than zero. Catch rates were expressed as indices. Generally the trend between the two datasets were similar (Figure 3.2). Overall the catch rate increased between 2002 and 2013 followed by a gradual decline and then remaining stable between 2015 and 2019. The increase in catch rate after 2002 is likely due to a change in fleet behaviour when the fleet started targeting Moreton Bay bugs. This coincided with an increase in market value for the species. Previously Moreton Bay bug were caught incidentally when other species were being targeted.

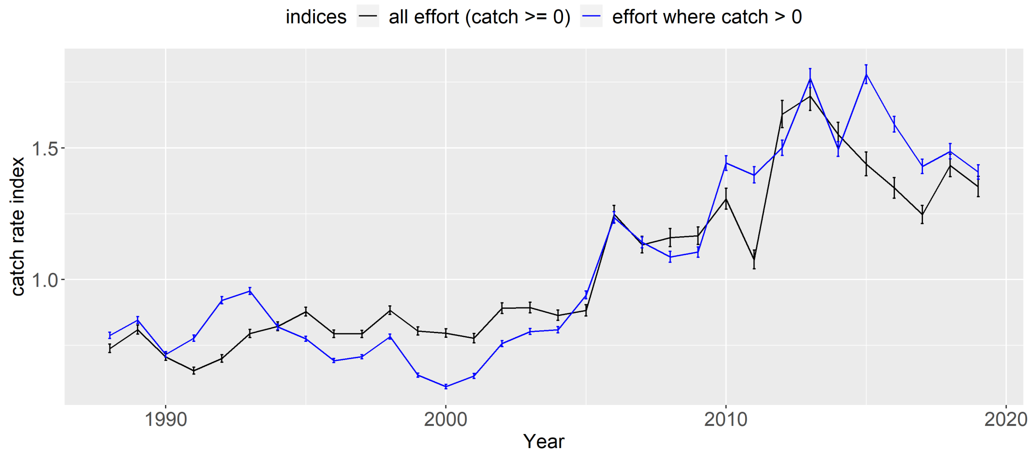

Figure 3.2: Annual standardised catch rates and standard errors for Moreton Bay bug from 1988 to 2019

The standardised catch rates are presented separately for the southern and northern fleet and against the fishery as a whole, to examine for any fleet specific contributions to the overall catch rate (Figure 3.3). Generally, in both fleets, the catch rate steadily increased between 2005 and 2013. After 2014 the trend between the fleets diverged and the catch rate from the northern fleet declined and the catch rate from the southern increased. These results suggest that the change toward targeting Moreton Bay bug was more pronounced in the southern fleet.

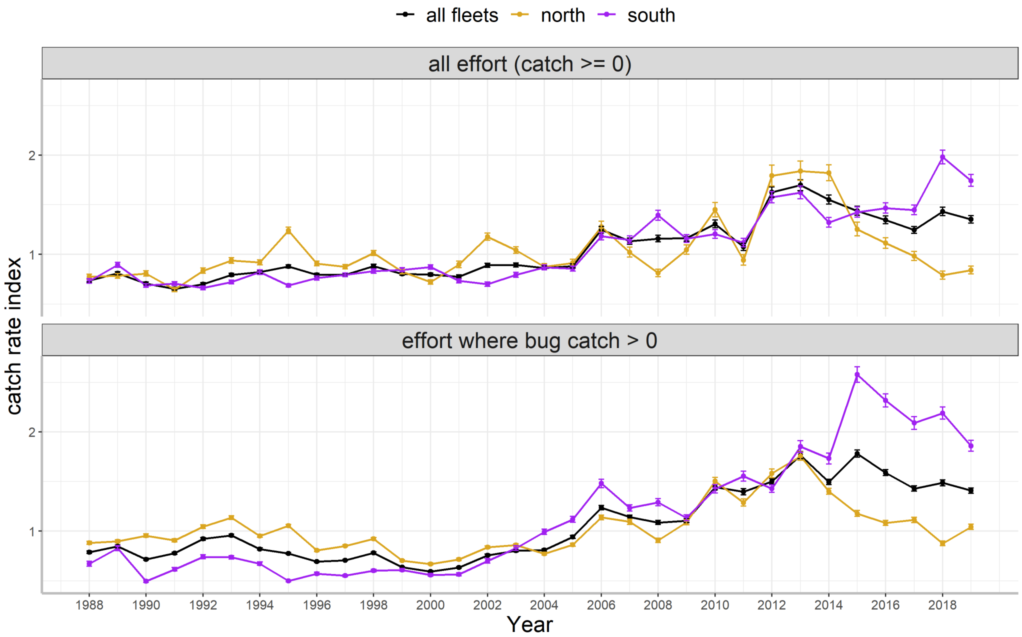

Figure 3.3: Annual standardised catch rates and standard errors for Moreton Bay bug from 1988 to 2019, for northern and southern fleet and the whole fishery

The change in catch rate trend with the addition of each new term in the general linear model is presented as a step plot in Figure 3.4. Results are presented for two sets of data: catches with all effort (effort where catches were greater than or equal to zero) and effort where Moreton Bay bugs catches were greater than zero. Generally the trends for each term was quite similar between the two datasets (Figure 3.4).

Figure 3.4: Variation in catch rates as each term was fitted sequentially

The influence of each term was further examined using data based on effort where catches were greater than or equal to zero and is presented in the Appendix C, Figure C.1. 'Grid' was the variable with the greatest influence on the difference between unstandardised (i.e. only 'year' term) and standardised catch rate within a given year is the variable that differs from its average (Appendix C Figure C.1). This may be due to the spatial distribution of the fishery varying over the years (Appendix C Figure C.3) and this is not unusual. Some vessels have left the fishery and of those vessels remaining some have more records in the latter years since 2000 than earlier in the history of the fishery (Figure C.2). Some grids have fewer records in later years (since 2002) than earlier in the history of the fishery, in the southern and northern fleet combined (Figure C.3). Notwitstanding the fewer records, it is possible that each record consist of a greater level of catch (per record) particularity in the southern fleet (Figure C.7).

References

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Appendix A Spatial distribution of catches

There are two distinct areas of concentrated catches, and indicative of two different fleets (Figure A.1). The geographic distribution of the two fleets, north and south, are also shown (Figure A.1). The fleet north of 22° S targets prawns (mainly redspot king and tiger) and the fleet south of 22° S targets scallops although there may have been a shift toward bugs. This spatial distribution of catches is based on TrackerMapper data which tracks the catch and position of each vessel from 2000 to 2019.

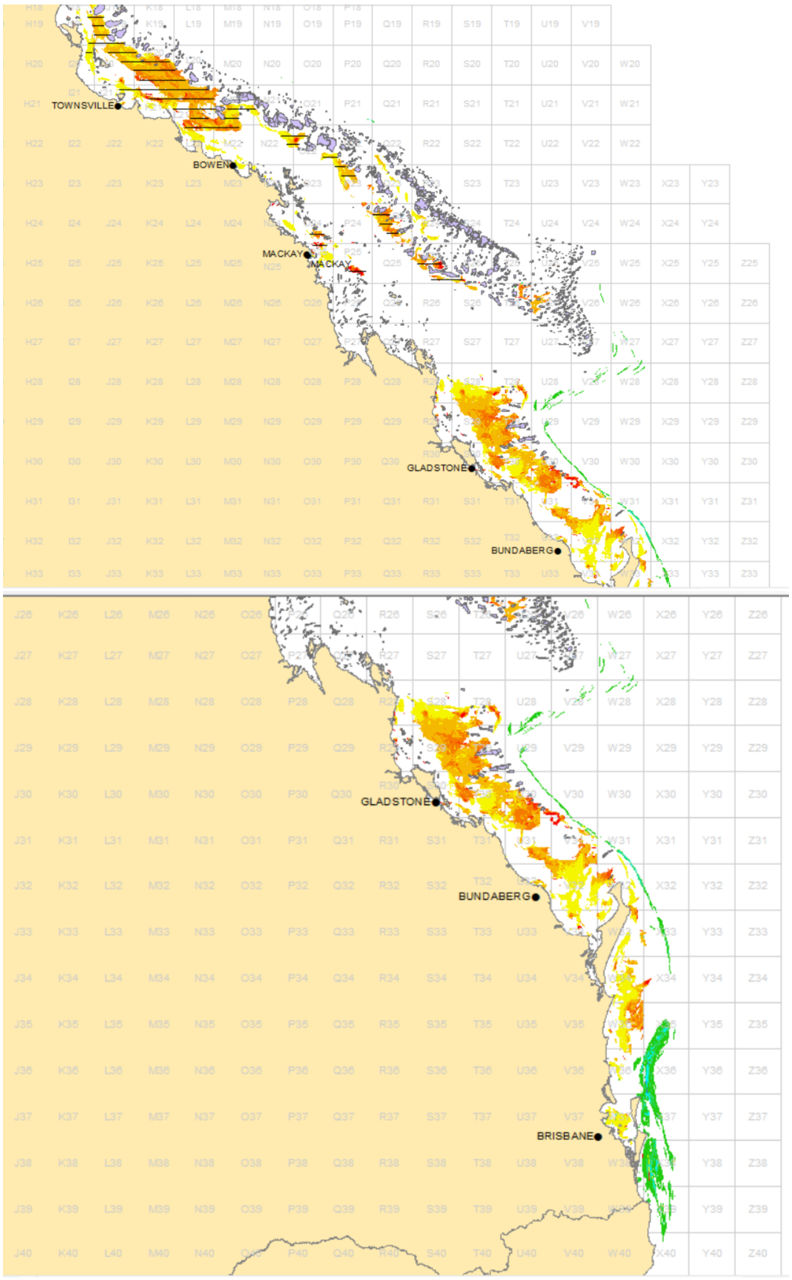

Figure A.1: Area of Moreton Bay bug catches of the northern fleet (top panel) and southern fleet (bottom panel) for all years combined between 2000 and 2019
Note: catches of Moreton Bay bug are depicted by orange and red areas and catches of Balmain bug are depicted by green areas

Appendix B Data filtering and selection criteria

The data were initially filtered based on species categorisation and to ensure that Moreton Bay bug were carefully categorised in amongst a mixed catch consisting of multiple bug species. TrackMapper data were used to indicate the areas where Moreton Bay bug was caught and where Balmain bugs were caught. The first step was to eliminate grids based on visual inspection of the TrackMapper data which tracked the spatial distribution of species caught. Grids for elimination were mainly Balmain bug grids and those grids deeper than the 80 m depth contour. Additional filters were formulated based on discussions. ‘True’ Balmain bugs are not likely to occur north of 22° S and therefore the purpose of selecting latitudes north of 22° S was to exclude Balmain bugs and include only Moreton Bay bugs. This takes into account mislabelling of species, where Moreton Bay bugs might be mislabelled as Balmain bugs.

Following the filtering criteria, further data selection criteria were applied. Data selection was based on where the bulk of the catch occurs as reported in the CFISH logbook database and are summarised in Table B.1. Following the data filtering and selection criteria, a comparison of remaining catches is presented in Figure B.1.

Table B.1: The data selection criteria used to specify and identify the fishery data to be included in the analysis

Property	Value
label	logbook East Coast Trawl
years	1988–2019
species common name	all bugs north of 22° S and Moreton Bay bugs south of 22° S
fishing method	trawl
Depth range	0–80 m
Vessel selection	Vessels with at least 2 years of fishing
grids	northern: C5, D10, I18, I19, I20, J19, J20, J21, K20, K21, L20, L21, L22, M21, M22, O22, O24, P23, P25, Q24, R25 southern: S28, S29, T28, T29, T30, U30, U31, V31, V32, W32, W33, W34, W35, W37

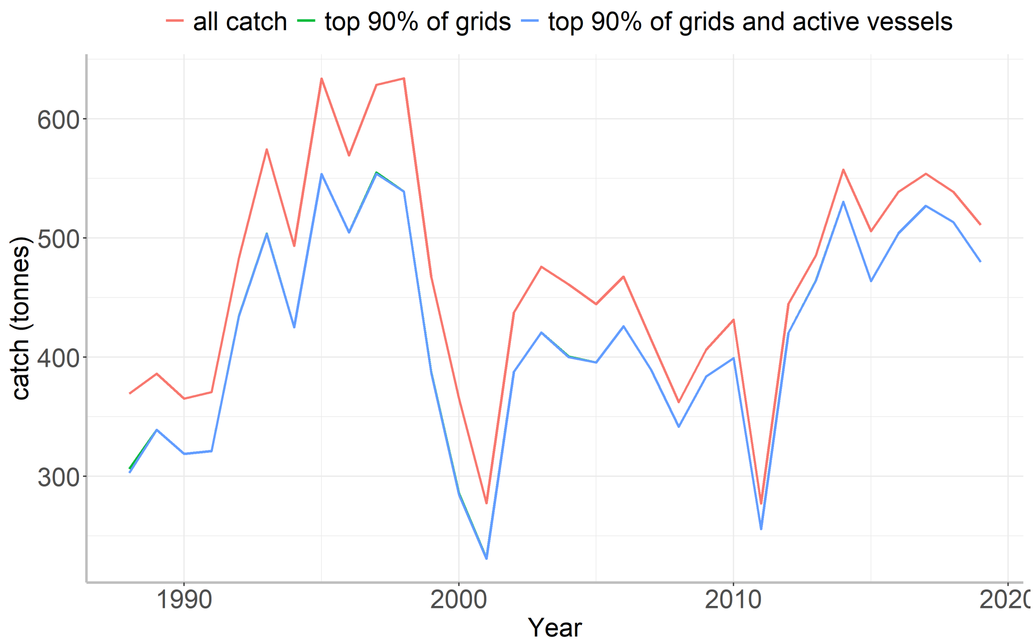

Figure B.1: Annual harvest of Moreton Bay bugs after applying data filtering and data selection criteria

Appendix C Diagnostic plots: influence plot

Each term considered within the model may influence the catch rate. To understand the patterns of annual influence by each term, a composite plot was presented which combines the coefficient values, the distributional changes, and the annual influence of each term into a single plot: the coefficient–distribution–influence (CDI) plot. It is well known that changes in the number of active vessels may occur over time and it is reasonable to consider the influence of vessel effects (Authority Chain Number, ACN) in addition to considering the 'grid' effect (Figure C.1). Henceforth the term 'vessel' will be used to refer to 'ACN'. The vessel term was examined further by CDI plots, both 'vessel' and 'grid' are presented (Figures C.2 and C.3). The CDI plots are composite plots that diagnose the annual influence and consist of three panels. The top panel is the normalized coefficients and standard errors (i.e. the catch rate index). The bottom left panel, is the bubble plot showing the proportion of records from each grid or vessel ACN in each year. The bottom right panel shows the annual values of influence (Bentley et al. 2012).

For the fishery as a whole, results indicate that despite a clear pattern in the number of active vessels participating in the fishery (Figure C.2), 'vessel' had only minor influence on the catch rate trend (Figure C.1). This was unexpected, particularly where management changes have resulted in changes in the number of vessels in the fleet. The 'grid' term had a higher influence (Figure C.1). For 'vessel', the CDI plot indicates that a number of vessels left the fishery, mainly after 2000, but these vessels had few records (smaller size circles in Figure C.2) and only made up a smaller proportion of the data compared to the vessels that had a greater number of records (larger sized circles in Figure C.2). The plots support the finding that 'grid' was influential, given that the number of records (size of the circles) within a grid varied between years (Figure C.3).

Additional information was revealed when the fishery was divided into a northern and southern fleet. In the northern fleet the effect of vessels were as equally influential if not more influential than the grid effect (Figure C.4). Results indicate that a proportion of vessels left the fleet and the number of records (size of the circles) increased after 2002 for that portion of the fleet that remained (Figure C.5). In the southern fleet, 'grid' was more influential (Figures C.6 and C.7).

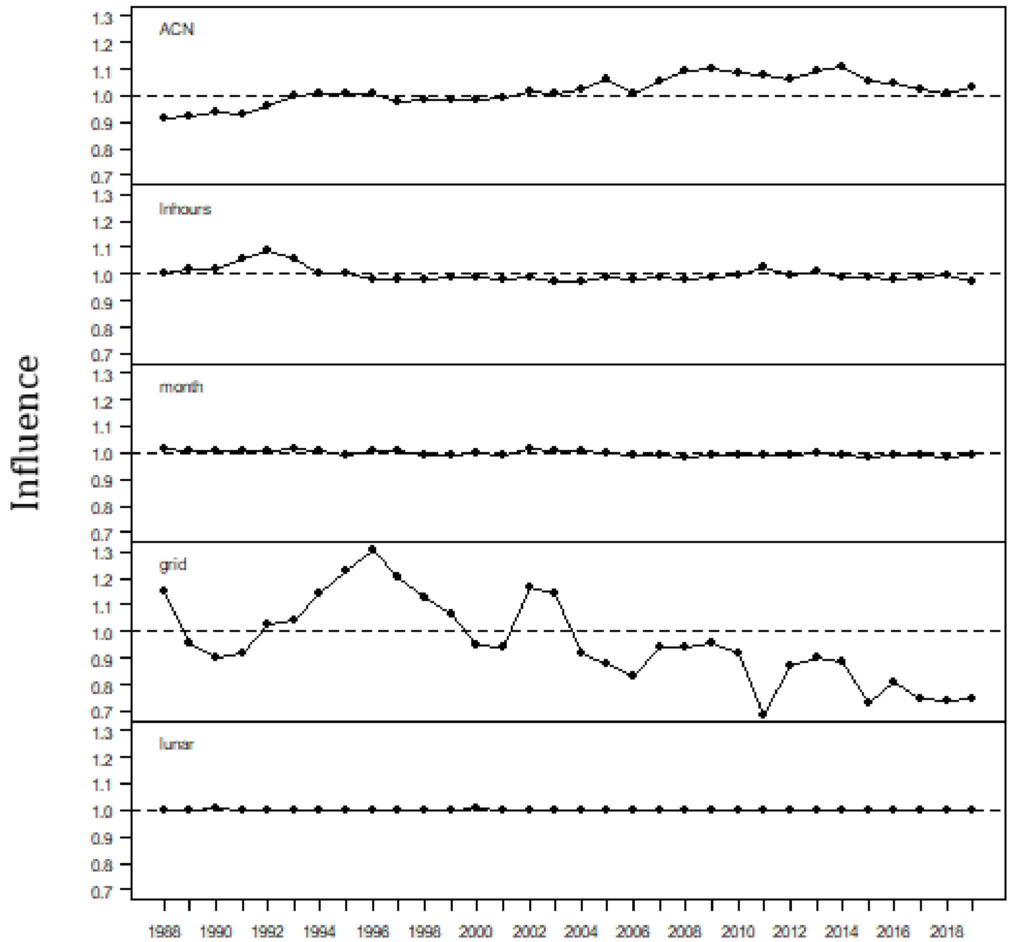

Figure C.1: Influence of model terms on catch rates for both fleets using data based on effort where catches were greater than or equal to zero

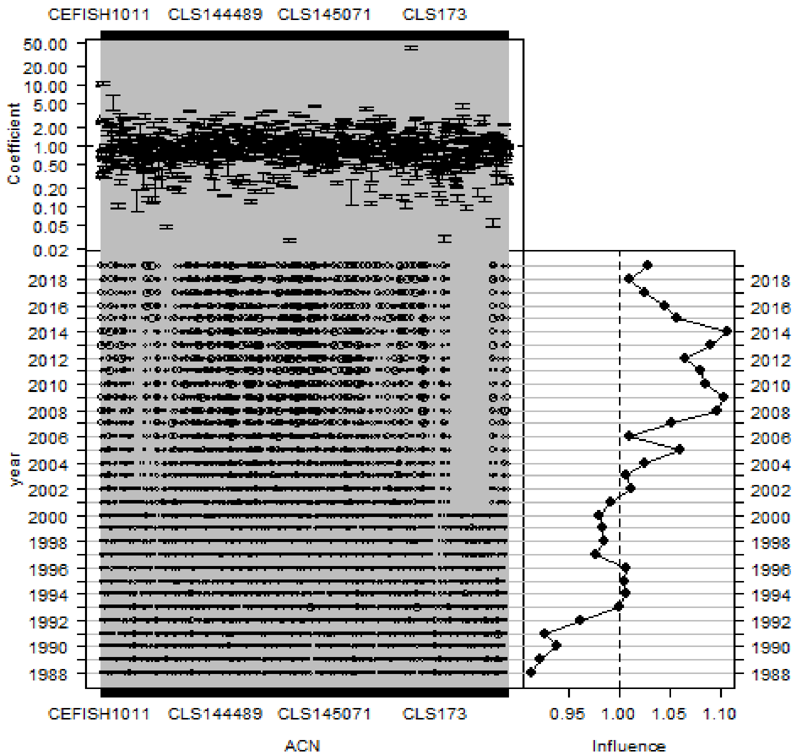

Figure C.2: The effect of 'vessel' (ACN) for the entire fishery (northern and southern fleet combined) using data based on effort where catches were greater than or equal to zero

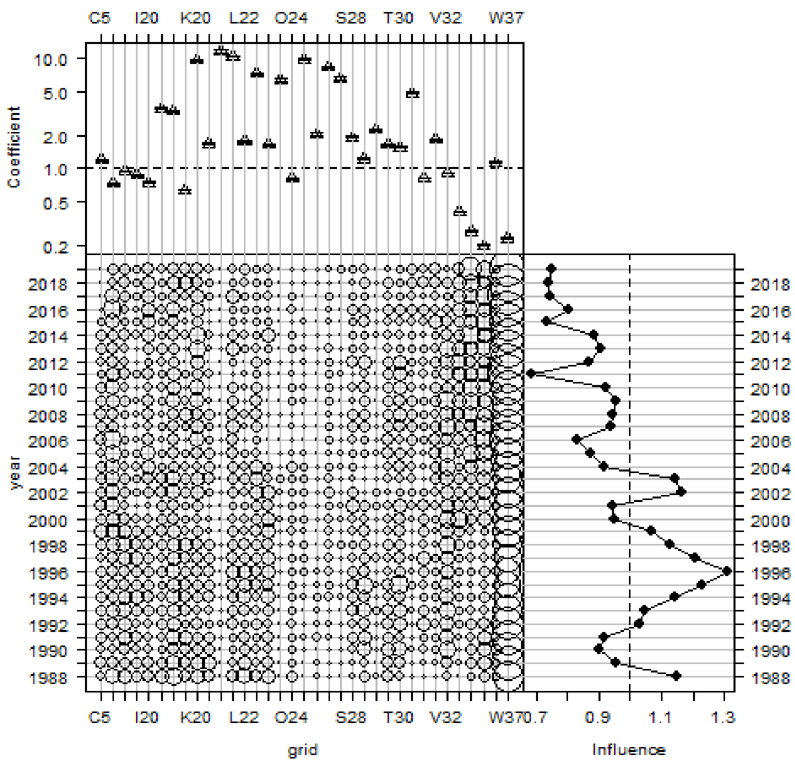

Figure C.3: CDI plot showing 'grid' effect for the entire fishery (northern and southern fleet combined) using data based on effort where catches were greater than or equal to zero

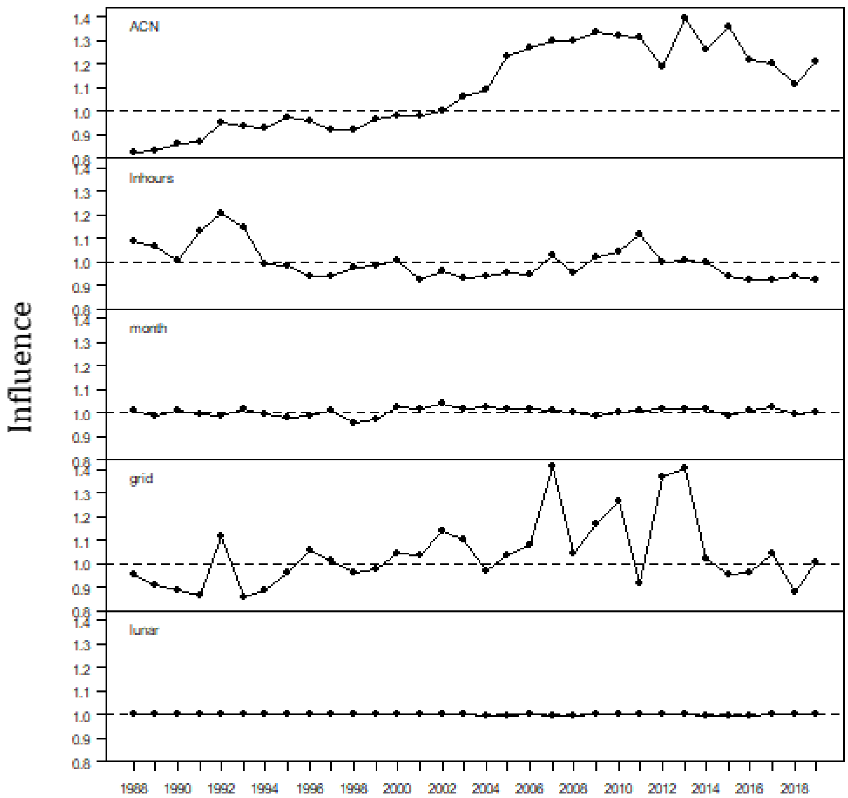

Figure C.4: Influence of model terms on catch rates for the northern fleet using data based on effort where catches were greater than or equal to zero

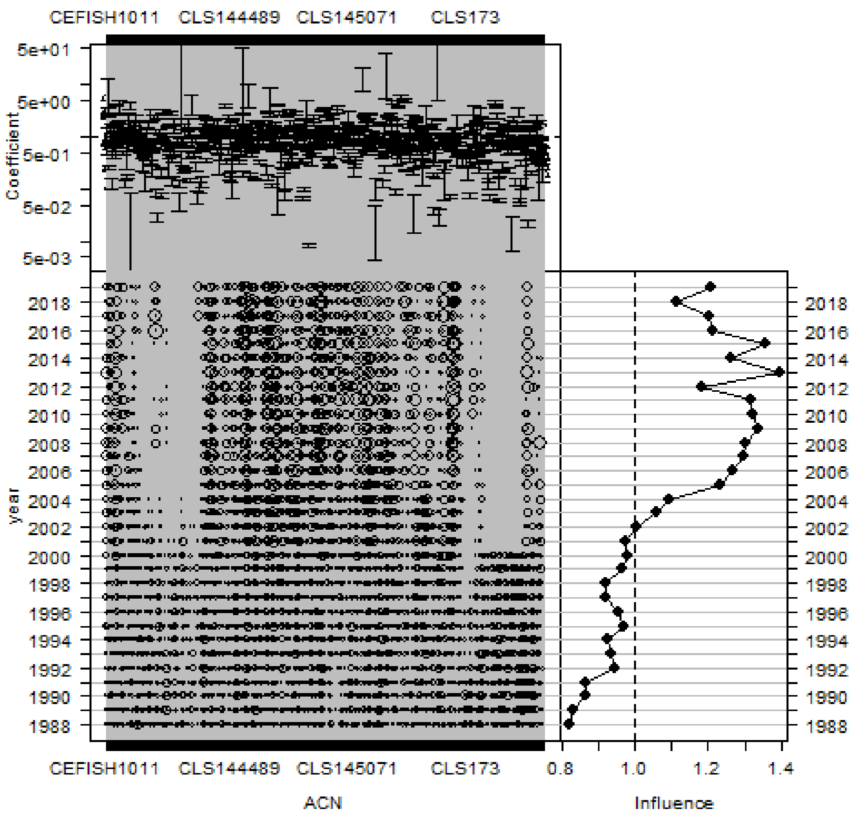

Figure C.5: The effect of 'vessel' (ACN) for the northern fleet using data based on effort where catches were greater than or equal to zero

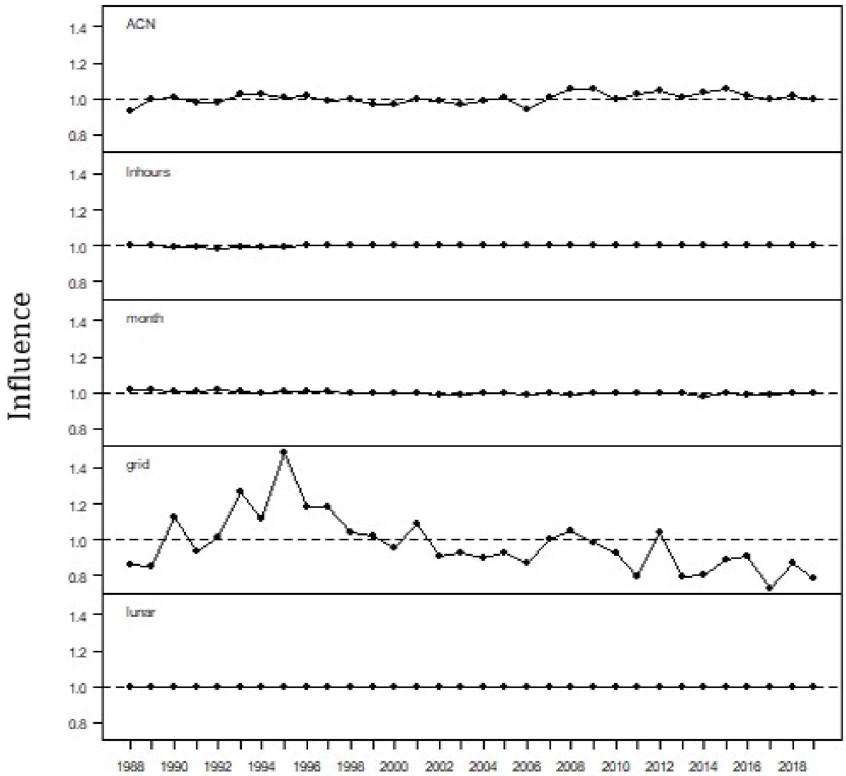

Figure C.6: Influence of model terms on catch rates for the southern fleet using data based on effort where catches were greater than or equal to zero

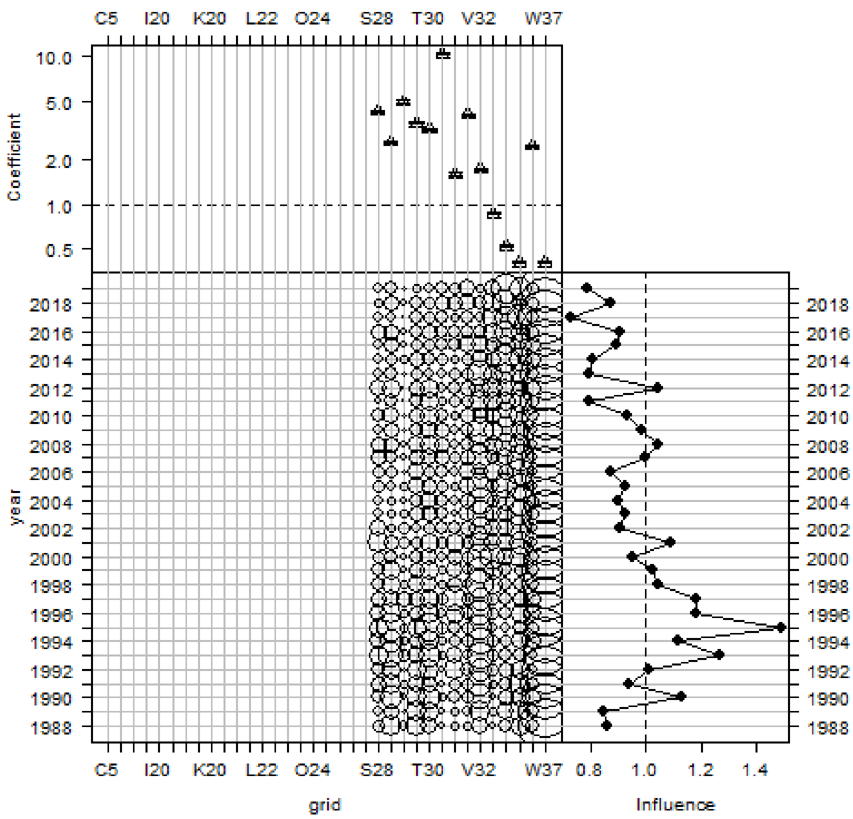

Figure C.7: The effect of ‘grid’ for the southern fleet using data based on effort where catches were greater than or equal to zero