TASMANIAN GIANT CRAB FISHERY - 13/14

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1 Executive summary

This assessment of the Tasmanian giant crab fishery covers the period from 1st March 2013 to 28th February 2014 and forecasts catch rates and biomass levels under current management arrangements.

In the last two years, the total catch has decreased substantially. The catch reported in the quota allocation system for the 2013/14 season was 25.95 tonnes, representing only 55.7% of the 46.6 tonne TACC. In the 2012/13 season the catch was similar at 26.41 tonnes, which was 56.7% of the reduced 46.6 tonne TACC.

State-wide catch rates were at records lows in the 2013/14 fishing season, currently 23% of the standardised 1995/96 catch rate. Regionally, catch rates were 27% on the West coast and 15% on the East coast. The state-wide catch rate in 2013/14 declined by 7% from 2011/12 and 5% from 2012/13, triggering the limit reference point for a decline across two consecutive years. The regional catch rates off the West and East coasts also declined by 9% and 8% respectively since 2011/12 but this was less than 20% so the limit reference point was not triggered.

Catch rates of undersize crabs (which are released) provide an indication of undersize abundance and consequently the strength of future recruitment to the exploitable biomass. The catch rate of undersize giant crabs has been declining since 2004/05 on the East coast and in 2013/14 was at 2% of the 2004/05 peak. On the West coast, undersize catch rates have almost quadrupled since 2009/10 and were at similar levels to 2003/04, which is a positive sign for future exploitable biomass. The reduction in the male size limit for the 2009/10 season can explain some of the reduction in undersize catch rates on the East coast, however there was already a substantial reduction in catch rate prior to the size limit change. This dramatic reduction in undersize catch rates on the East coast is a concern for the future health of the exploitable biomass.

Reference points relating to the weight structure of the catch landed at processors are no longer assessed due to the availability of a stock assessment model. The stock assessment model uses the length frequency data collected by fishers in addition to commercial catch and effort data, to provide more reliable and higher resolution size structure and biomass data.

The stock assessment model estimates that the state wide exploitable biomass has declined from a maximum of approximately 1100 tonnes in the early 1990s to 106 tonnes in 2013/14. This equates to 9% of the original unfished exploitable biomass. Total biomass and egg production have both decreased to 13% and 14% respectively of their initial levels but have started to stabilise over the last two fishing seasons. Due to significant undercatch, estimated harvest rates have

remained steady over the last two fishing seasons at around 25% state-wide.

Results for the West coast are indistinguishable from the state wide results when considered relative to the virgin stock state. Total biomass and egg production have both decreased to 14% of their initial levels but have been relatively stable for the last three fishing seasons with slight improvement. Estimated harvest rates have remained steady over the last two fishing seasons at around 22%.

The East coast stock is smaller but has had proportionately lower catches. Consequently the stock is less depleted at 14% of Virgin exploited biomass and 20% egg production. The harvest rate has declined to 22% (the same as the West coast). There is more uncertainty about the East coast stock due to the limited availability of length frequency data. Length frequency data from the East coast is urgently required to reduce uncertainty in the assessment.

The stock assessment projections for the 2014/15 TACC with a 10% undercatch (34.3 tonnes) over the next decade were positive at all three spatial scales. Statewide catch rates, absolute egg production and exploitable biomass are projected to stabilise and rebuild to 52%, 78% and 56% greater than present levels respectively by 2023. East coast catch rates, absolute egg production and exploitable biomass are also projected to stabilise and rebuild to 47%, 64% and 54% greater than present levels respectively by 2023. Similarly, West coast catch rates, absolute egg production and exploitable biomass are projected to stabilise and rebuild to 58%, 68% and 50% greater than present levels respectively by 2023.

Catch rates of giant crab in 2013/14 have continued to decline, which was not predicted by the previous stock assessment despite actual catches being substantially lower than those that were modelled. This raises concern that the observed catch rate declines are due to external factors not modelled. While model projections indicate stability in the future, there is much uncertainty with these outputs because length frequency data is not available from the East coast stock and growth information is limited. Consequently, the positive model based outlook should be treated cautiously.

Table 1: Summary of performance indicators for giant crab.

Performance indicator	Reference point	Triggered	Status in 2013/14
Total yearly catch	Yearly catch $<$ 90% of TAC	Yes	55.7%
State-wide commercial catch rates	Decline in two consecutive years	Yes	7% decrease
Regional commercial catch rates	Total decline by 20% in 2 years	No	
Bycatch by lobster fishers	Catch $>$ 5 tonnes	No	
Proportion of catch over 5 kg	Varies $>$ 30% from reference year	N/A	Size structure data now derived from catch sampling and used in estimation of biomass
Proportion of catch below 3 kg	Varies $>$ 30% from reference year	N/A	Size structure data now derived from catch sampling and used in estimation of biomass

2 Introduction

This assessment of the Tasmanian giant crab fishery covers the period between 1989/90 to 2013/14. It considers the performance of the fishery against the agreed set of reference points defined in the giant crab management plan (DPIPWE, 1999) and updates the annual assessment for the period from 1 March 2013 to 28 February 2014. Other information is provided to assist in assessing the state of the resource including results from the giant crab stock assessment model, and forecasts of the likely outcome of a 10% undercatch of the TACC over the next decade.

The commercial fishery for giant crab began in Tasmania in the mid 1990s after a live export market to Melbourne, Sydney and Asia was established (Gardner, 1998). Giant crabs had previously been landed as byproduct of rock lobster fishers operating in deeper waters but were generally regarded more as a nuisance than a target. Once giant crab became a targeted species, catches increased dramatically. By 1994/95, total reported catch in Tasmanian waters peaked at 291 tonnes (Figure 1). While some of this catch may be attributable to over-reporting of catch in anticipation of a change in management (moving to quota), it is certain that large quantities of crabs were taken as the virgin stock was being fished down.

By the end of the 1997/98, the total catch had fallen to just 110 tonnes and some concerns were expressed about the downward trajectory of catch rates. At this time quota management was introduced to the associated rock lobster fishery. There was concern that this would displace effort from the rock lobster fishery to the giant grab fishery. In response a giant crab management plan introduced an Individual Transferable Quota (ITQ) system and an initial TAC of 103.5 tonnes in November 1999. The quota year mirrored that for rock lobsters running from 1 March to the end of the following February (DPIPWE, 1999). Along with the introduction of a TAC, a maximum size limit was set at 215 mm carapace length for both males and females, while the minimum legal length of 150 mm for both sexes, introduced in 1993, was retained.

In response to ongoing declines in catch per unit effort (CPUE) across much of the fishery and poor performance against indicators (Gardner et al., 2004), the TAC was reduced to 62.1 tonnes for the 2004/05 quota season before being reduced again to 51.75 tonnes in 2009/10 and finally to 46.6 tonnes in 2013/14. On the basis of a bioeconomic analysis (Gardner et al., 2009) both the TAC and the minimum legal size limit for males (to 140mm) were reduced for the 2009/10 season and the maximum size limit for males removed for the 2013/14 season. This aimed to increase biomass, catch rates and profitability.

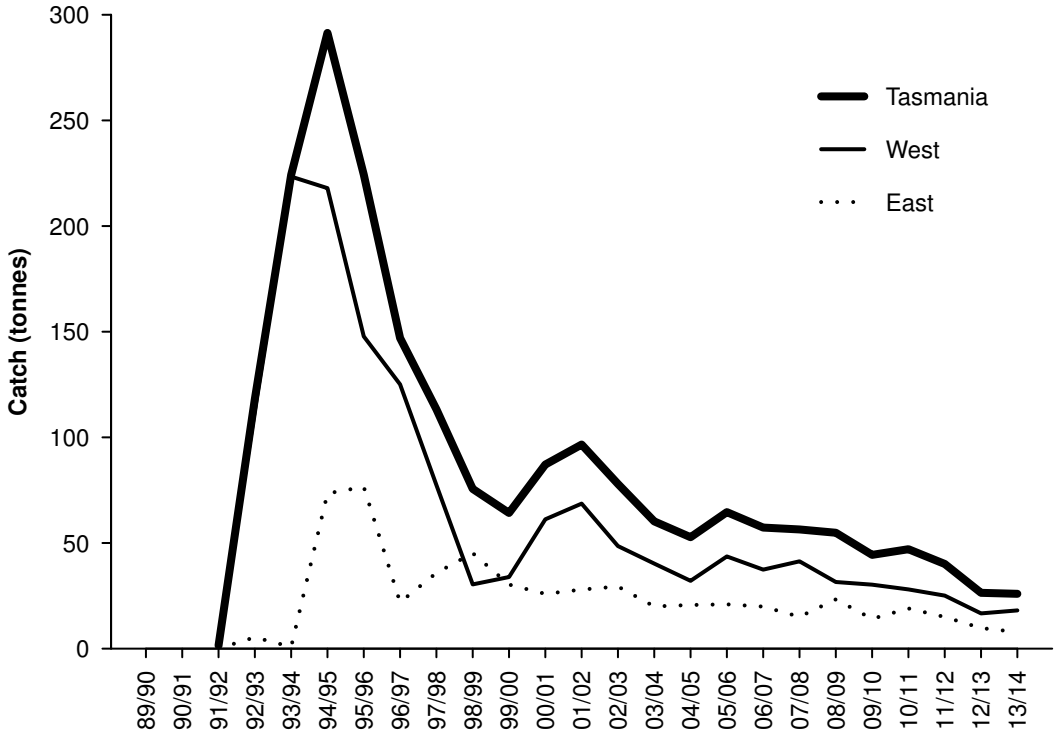

Figure 1: Historical giant crab catches in Tasmania. Catches in 1998/99 and 1999/00 were from partial fishing years due to an extended seasonal closure. East and West are divided by longitude 147°E.

3 Management objectives and strategies

The Tasmanian giant crab management plan was introduced in 1999 (DPIPWE, 1999) and provides the regulatory framework for the commercial fishery. The plan contains the following objectives, strategies and performance indicators.

3.1 Major objectives

Maintain fish stocks at optimum sustainable levels by constraining the total catch and the size of individual giant crabs taken by the commercial sector;

- Sustain yield and reduce incidental fishing mortality by taking fish at a size likely to result in the optimum yield from the fishery, protecting under-size giant crabs, and minimising incidental fishing mortality as a result of fishing operations;
- Manage commercial fishing interactions by mitigating any conflict that results from competition between different fishing methods for access to shared fishing grounds;
- Provide socio-economic benefits to the community;
- Provide high quality products.

3.2 Primary strategies

- Limit the targeted commercial catch by setting a total allowable commercial catch (TAC) and using individual transferable quotas (ITQs) to allocate proportions of the TAC;
- Limit access to by-catches of giant crabs.
- Maintain minimum and maximum size limits and closures of the fishery for female giant crabs during the peak spawning period to conserve egg production, restrict fishing mortality on spawning or berried female giant crabs, and ensure a proportion of large males and females are returned to the water;
- Maintain escape gaps to reduce incidental fishing mortality;
- Restrict the number of giant crab fishing vessels in the fishery and the number of giant crab traps that can be used from individual fishing vessels.

3.3 Performance indicators and reference points

The giant crab management plan identifies (but is not limited to) a number of fishery performance indicators. Reference ranges defined for these indicators are deemed to represent the normal variation of the stocks and fishery. When the observed value of a performance indicator falls outside this range, a limit reference point or trigger point is said to have been exceeded, implying that some management action may be required. Reference points are exceeded when one or more of the following criteria are met:

- The total yearly catch does not exceed 90% of TAC in any year;
- Catch per unit effort (CPUE) for the State declines for two consecutive years;
- Catch per unit effort (CPUE) for any region declines by a total of 20% in two years;
- The bycatch of giant crabs taken by rock lobster fishers exceed 5 tonnes in any year;
- The proportion of the catch above 5 kg or below 3 kg varies by more than 30% compared to the 1996/97 distribution.[1]

[1]This performance indicator was intended to provide information on changes in the size structure of the stock. Length-based information is now collected in much greater resolution through on-board catch sampling conducted by commercial fishers, and used as an input to the assessment model to provide more informative measures on biomass and egg production.

4 Fishery Assessment

4.1 Commercial catch

Giant crab catch is recorded by both the quota allocation system and through logbooks. However these records (as listed in Table 2) do not correspond completely. The quota is considered as taken only when animals are sold or landed, while an entry in a fisher's logbook records the date of capture, and it is quite common for a fisher to hold animals for extended periods. There will also be some transcription errors as evidenced by the need to adjust unrealistic weights and catch rates in the database.

In 2013/14 the total catch reported in logbooks was 26t whilst 26.4t was recorded by the quota monitoring system. This corresponds to only 56.64% of the TAC. Similarily, in 2012/13 only 58.49% of the TAC was landed (Table 2, Figure 2). Low catches relative to the TAC are common in this fishery, which have been attributed to a range of factors outlined in more detail below.

Table 2: Catch totals in tonnes by quota year (March to February) from 1989/90 until present as reported in logbook returns (Tasmania, West and East), landed catch from quota allocation system, and Total Allowable Commercial Catch (TAC). West and East are defined as either side of longitude 147°E.

Quota year	Tasmania	West	East	Landed catch	TAC
1989/90	0.2	0.1	0.1		-
1990/91	1.7	1.6	0.1		-
1991/92	1.5	1.4	0.1		-
1992/93	118.2	112.8	5.4		-
1993/94	224.2	223.4	0.8		-
1994/95	291.4	217.9	73.5		-
1995/96	224.3	147.8	76.6		-
1996/97	147.0	125.1	21.9		-
1997/98	113.3	77.4	35.9		-
1998/99	75.6	30.4	45.2		-
1999/00	64.2	33.9	30.3	61.3	103.5
2000/01	87.1	61.2	25.9	89.8	103.5
2001/02	96.6	68.6	28.0	94.5	103.5
2002/03	78.0	48.5	29.4	74.1	103.5
2003/04	62.3	42.3	20.0	61.6	103.5
2004/05	52.7	32.1	20.7	46.2	62.1
2005/06	64.6	43.6	21.0	59.7	62.1
2006/07	57.3	37.4	19.9	53.1	62.1
2007/08	56.4	41.3	15.1	49	62.1
2008/09	54.9	31.5	23.3	52.6	62.1
2009/10	44.4	30.3	14.1	46.3	51.75
2010/11	47.1	28.0	19.0	47.0	51.75
2011/12	40.1	25.1	15.0	44.1	51.75
2012/13	26.4	16.7	9.7	27.3	46.6
2013/14	26.0	18.1	7.8	26.4	46.6

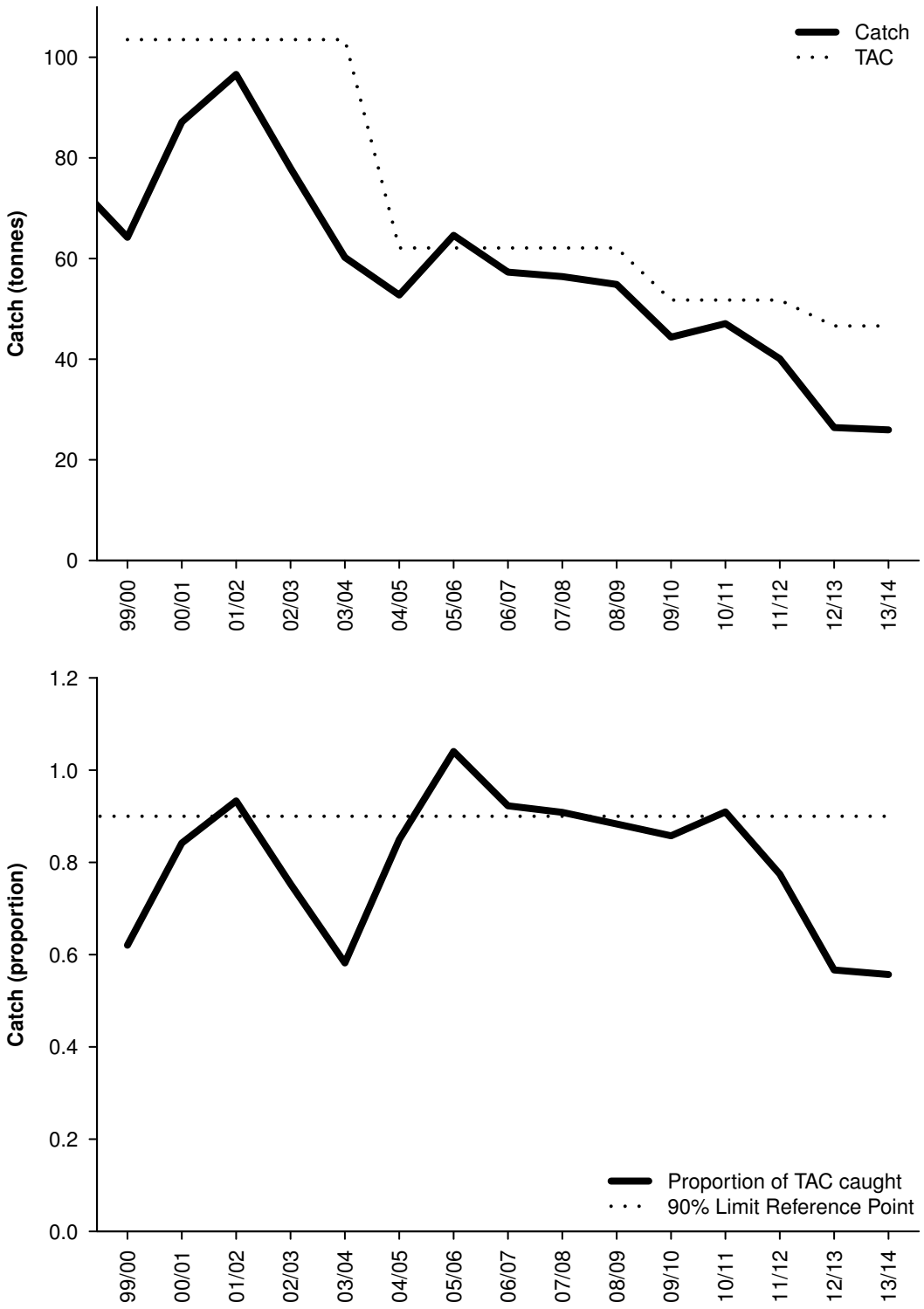

Figure 2: Total catches from logbook records and TAC since quota management was introduced (top), and the proportion of the TAC caught in each year (bottom). The dashed line marks the 90% limit reference point.

In the current assessment period 18.1t was taken from the West coast in 2013/14. The remainder was taken from the East coast – 7.8t. These catches are the lowest since 91/92 (East coast) and 93/94 (West coast) (Table 2). The ratio in catch from the two regions appears to have stabilised since 2000/01 with between 30 - 40% of the catch taken in the east and between 60 - 70% in the west (Figure 3).

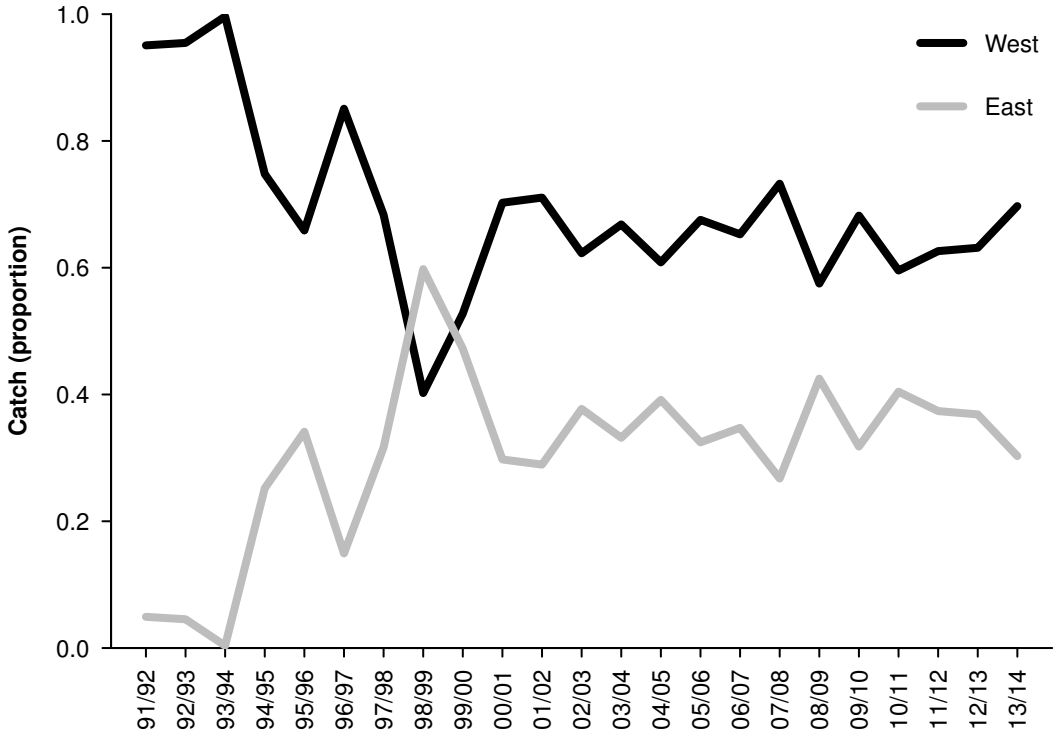

Figure 3: Relative catches coming from the East and West coasts in each quota year.

Changes in the concentation of quota holdings were examined using two indices of concentration: the adjusted Gini Coefficient (GC) and the normalised Herfindahl-Hirschman Index (HHI). These indices are commonly used in economics to measure inequity in wealth distribution and in this context provided a measure of concentration among quota holdings of Tasmanian giant crab fishers, as similarly used by (Emery et al., 2014) for Tasmanian rock lobster fishers. The GC ranges from zero to one, with zero representing equal concentration (i.e. all fishers hold an identical number of quota units) and one representing total concentration (i.e. one fisher holds all the quota units). The HHI ranges from $1/n$, where n is the number of quota holdings in the fishery. The HHI increases both as the number of fishers with quota holdings decrease and as the concentration in quota held between those

fishers increases.

The GC of the Tasmanian giant crab fishery declined from 0.73 in 2009/10 to 0.6 in 2012/13 before rising slightly to 0.65 in 2013/14. this reduction in concentration was also evident in the HHI, which declined from 0.12 in 2009/10 to 0.04 in 2012/13 before rising slightly to 0.06 in 2013/14 (Figure 4). This is an indication that over the last few fishing seasons, fishers have been reluctant to lease in large amounts of quota to supplement their current holdings relative to previous seasons. This is reinforced by the fact that the average size of quota holders has almost halved (from 1,617 in 2009/10 to 932 in 2013/14) and the number of quota holdings doubled (from 32 in 2009/10 to 50 in 2013/14), highlighting the inability of owners to lease out units or reluctance of fishers to lease in additional units (Table 3). In 2013/14, the top 20% of quota holdings made up 74% of the total quota units in the fishery compared to 83% in 2009/10, another indication that concentration has reduced in the fishery (Figure 5). Some of the reluctance of fishers to lease in additional units or fish the units they owned is reported to have been due to loss of market access, the inability to undertake dual-endorsed trips (e.g. fish on a single trip for both crab and rock lobster) and new regulations preventing the unloading of giant crab interstate. After separate analysis of the rock lobster catches from owners with the largest giant crab quota holdings, there was no evidence suggesting they had increased fishing for rock lobster at the expense of giant crab over the last few fishing seasons.

Table 3: The proportion of the Total Allowable Catch (TAC) undercaught in the fishery as reported in the quota management system, the number of quota holders (i.e. those with owned or leased in quota units) and the average size of their quota holding from 2009/10 until present.

Quota year	% of TAC undercaught	No. quota holders	Avg. size of quota holding
2009/10	10.58%	32	1617
2010/11	9.16%	30	1725
2011/12	14.82%	31	1669
2012/13	41.51%	55	847
2013/14	43.36%	50	932

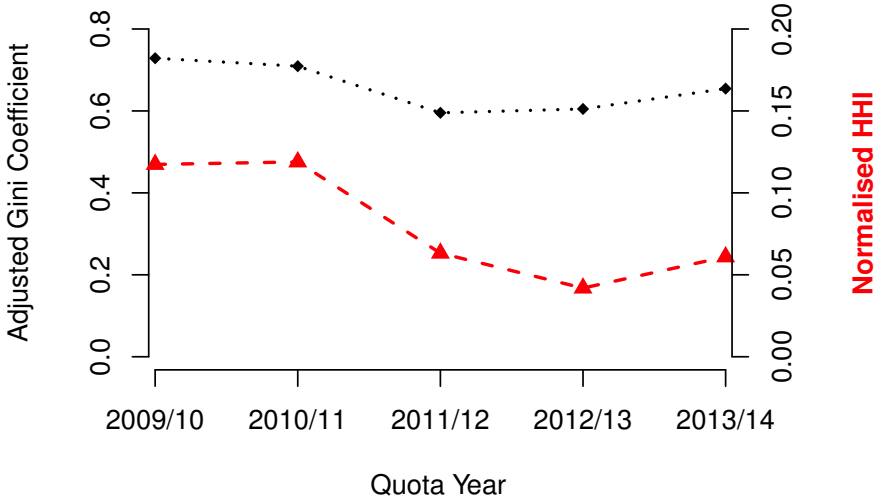

Figure 4: Change in the concentration of quota holdings between the 2009/10 and 2013/14 fishing seasons using the adjusted Gini Coefficient and normalised Herfindahl Hirschmann Index.

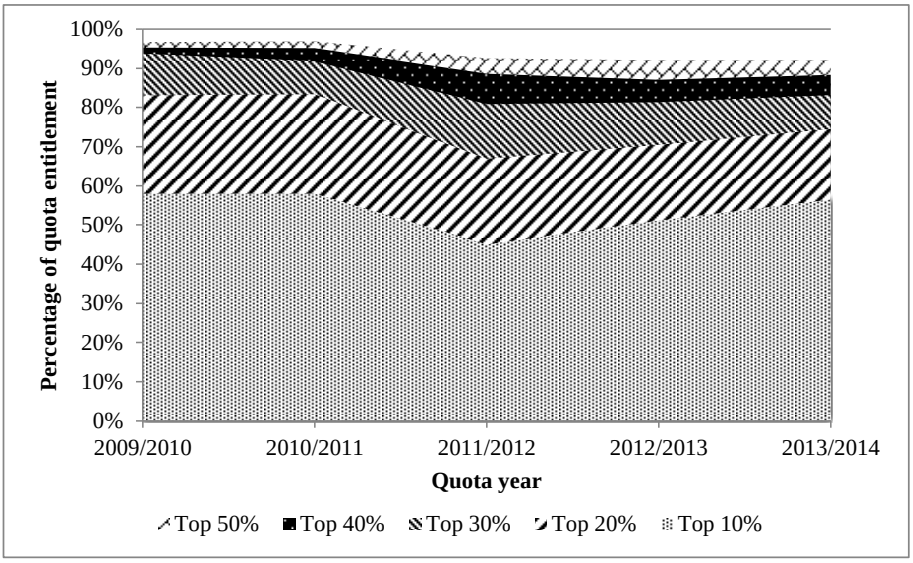

Figure 5: Change in the concentration of quota holdings amongst a percentage of the top entitlement holders between the 2009/10 and 2013/14 fishing seasons.

4.2 Commercial catch taken by other sectors

Giant crabs are also taken by Southern, Eastern Scalefish and Shark (SESS) trawlers, but determining the catch of giant crabs from this sector is difficult. Catch records collected by the Australian Fisheries Management Authority (AFMA) identify most of the crab catches simply as 'crab' and without catch locations. Information on the species composition of this 'crab' catch is potentially available through observer data and species composition of reported landings where species is identified. Observer data on the species composition of crab catch has not be obtained, thus the only information on crab catch by trawlers comes from landings data.

From 2002-2013 inclusive, total landings of 112 tonnes of crabs were reported from trawlers into ports in Tasmania, SA, Victoria and NSW (Table 4). Most of these landings are for unspecified crabs (81t), while only three crab species were identified - giant crab with 31.7 tonnes, crystal crab *(Chaceon bicolour)* with 0.02 tonnes and champagne crab *(Hypothalassia acerba)* with 0.02 tonnes.

The fishing location is not recorded and the landing state provides a poor indication – e.g. NSW has 15% of the catch identified as giant crab, however giant crabs are rarely found in NSW. It is possible that the reported landings of unspecified crab catch are predominantly, or even entirely, giant crab and caught in Tasmanian waters. Consequently giant crab catches by SESS trawlers in 2004 could have been as high as 19.6 tonnes (31% of the Tasmanian giant crab TAC), and accounting for the trap fishery only would therefore mean a substantial underestimation of the total catch removed from Tasmanian waters. In recent years the total SESS crab catch has been increasing from around 3.9 tonnes in 2010 to 8.4 tonnes in 2013 – approximately 18% of the Tasmanian TACC in 2013/14.

Table 4: Crab catches (t) in the SESS trawl fishery between 2002-2013 by landing state.

Species	State	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Giant crab	NSW	0.2	1.3	0.7	0.9	0.5	0.4	0.2	0.1	0.1	0.2	0.1	0.1	4.9
	SA	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.5
	TAS	0.9	1.2	1.5	1.4	1.2	0.8	1.1	0.6	0.4	0.6	0.7	0.6	10.9
	VIC	1.4	1.5	1.5	1.3	1.2	0.9	1.1	1.4	1.0	1.1	1.3	1.2	14.9
	Total	2.5	4.1	3.8	3.7	3.0	2.0	2.5	2.1	1.4	1.9	2.1	1.6	31.2
Crystal crab	TAS					0.01								0.01
	VIC						0.01							0.01
	Total					0.01	0.01							0.02
Champagne crab	VIC												0.02	0.02
	Total												0.02	0.02
Unsp. crabs	NSW	2.7	5.9	3.8	3.1	3.9	1.9	0.7	1.2	1.4	0.5	1.2	2.0	28.4
	SA	0.1	0.2	0.1	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.6
	TAS	1.8	1.6	0.8	0.6	0.3	0.2	0.2	0.2	0.0	0.1	0.3	0.1	6.1
	VIC	5.0	8.2	8.6	4.8	4.4	0.8	1.7	1.8	1.0	1.7	3.0	4.3	45.5
	Total	9.6	15.9	13.2	8.5	8.8	2.9	2.6	3.3	2.4	2.3	4.5	6.4	80.6
Total		12.1	20.0	17.0	12.2	11.8	4.9	5.1	5.4	3.8	4.2	6.6	8.0	111.1

4.3 Commercial effort

Total fishing effort has remained within historical ranges with effort fluctuating more in the east than west (Figure 6). Overall, there was no unusual shift in seasonal effort in 2013/14 with fishing again mostly restricted to the start and end of the fishing season in autumn and summer, respectively. State-wide seasonal effort was below the historic range for most of the fishing season with the exception of May 2013 and February 2014 (Figure 7).

Since crab fishers typically operate across different fisheries, these trends in seasonal effort can be a function of activity in other fisheries such as the scallop and rock lobster fishery. The low effort applied over the winter months in the fishery is possibly due to the prohibition on the taking of berried females during this period, so fishing is less profitable and the fleet responds by reducing effort.

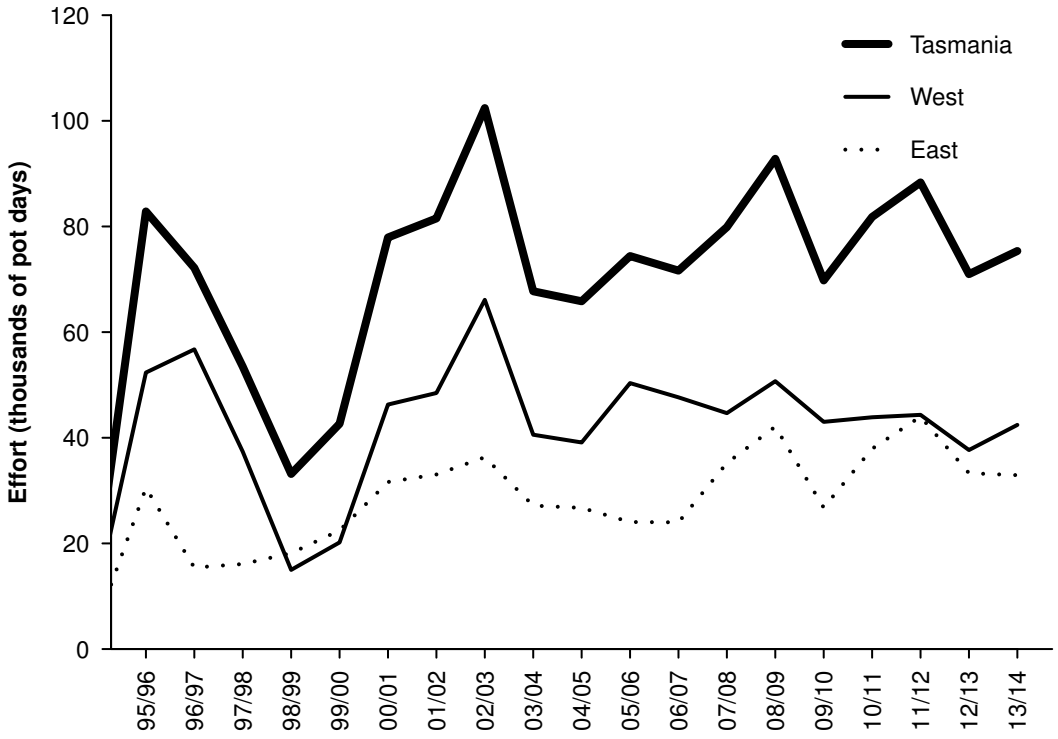

Figure 6: Total effort (pot days) and effort overall and for the West and East coast by quota year since 1995/96. Note that 1998/99 and 1999/00 were partial fishing years.

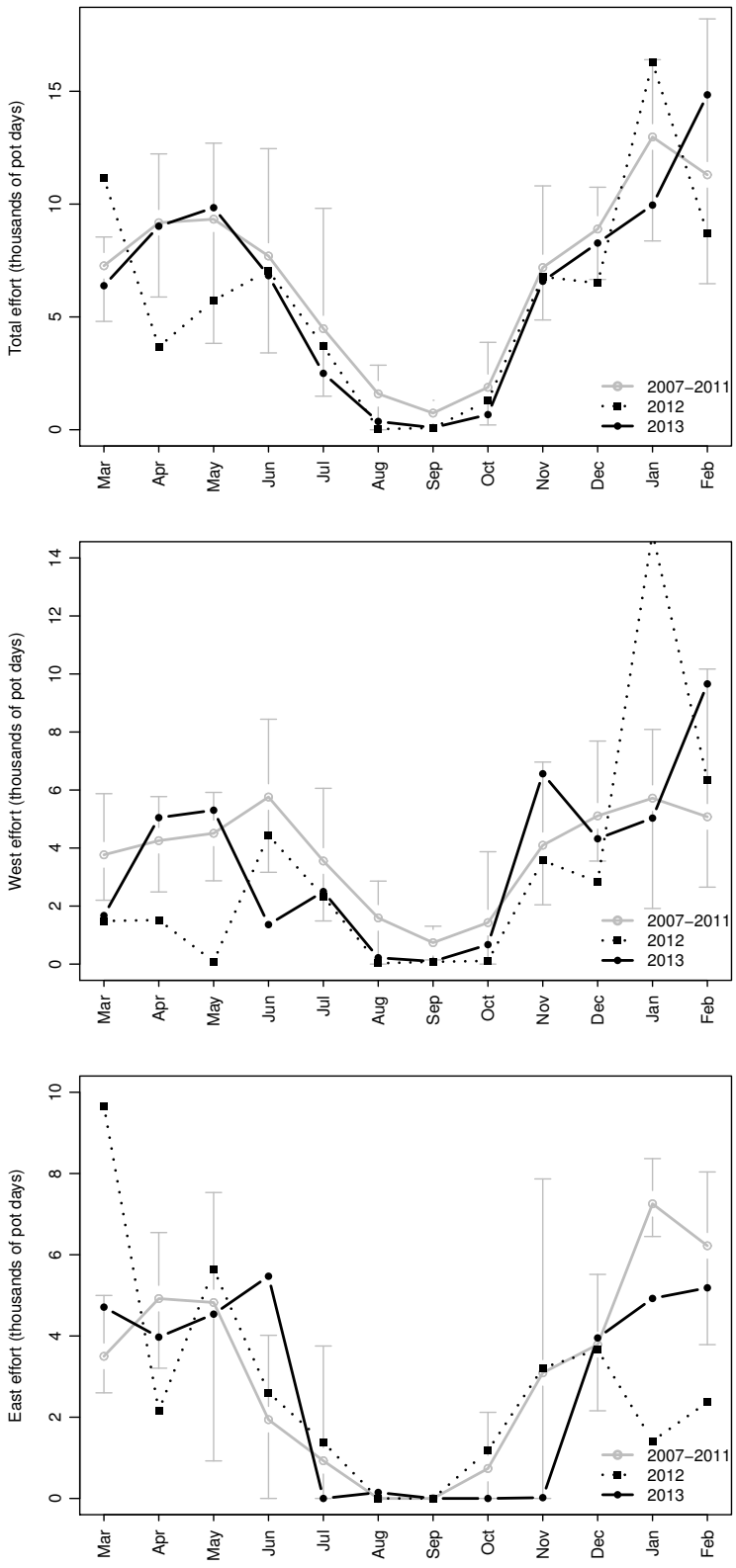

Figure 7: Seasonal trends in effort State-wide (top panel), on the West coast (middle panel) and the East coast (bottom panel). The 2012/13 and 2013/14 quota years are indicated by black dotted and black solid lines respectively. The average for the previous 5 years is indicated by the grey line; the error bars indicate the range of observed effort in that five year period.

4.4 Commercial catch rates

Commercial catch per unit effort (CPUE) or catch rates are drawn from commercial logbooks. Logbook data prior to January 1995 do not include a measure of effort (number of traps), so only data since the 1995/96 quota year can be used for calculating catch rates. The data have been processed for a range of factors:

- Misreporting of effort was a common problem early in the fishery. Records that were known to be false or appeared unreliable, e.g. low trap numbers or unrealistic high catch rates, have been excluded from the analyses.
- Crabs are often taken incidentally to lobster fishing and catch rates under these situations are believed to be quite different to when crabs are targeted. The analysis of catch rates here was restricted to targeted effort. Fishers note in the current logbooks whether their effort is targeted towards giant crab, but this was not the case prior to 2000. As an alternative approach to defining targeted effort and to perform an analysis for the whole of the period since 1995/96, logbook data were restricted to skippers that had reported a median catch of at least 1000 kg over a minimum of 2 years. This selected experienced fishers who use vessels and gear more suited to crabs and take most of the overall crab catch, while fishers that directed most of their fishing effort towards lobsters and tended to have lower catches and catch rates were excluded.

For seasonal catch rate trends, catch rates were estimated as kilograms per pot day for each record in the database as:

$$CPUE = \frac{\text{Weight of catch (kg)}}{\text{Number of traps} \times \text{Soak time}} \tag{1}$$

where pot days are defined as the number of traps multiplied with number of days the traps are in the water before being hauled (soak time). Although soak times greater than 7 days do not lead to increases in catch, capping soak times at 7 days had only minimal influence on the results and was not used.

Catch rates are used as a proxy for stock abundance in a fishery, however catch rates respond to a number of factors including the fishing block, month, skipper, depth and interannual variation in stock abundance. For example, a decrease in catch rates may be attributable to a new inexperienced entrant to the fishery or decreased stock abundance or a intra-annual shift in effort distribution. To address these concerns the catch rates here have been standardised using the methods

detailed in Appendix 2 in Ziegler et al. (2009). This standardisation gives the best estimate of inter-annual changes in catch-rates not due to the previously mentioned confounding factors.

4.4.1 Annual commercial catch rates

State-wide catch rates have declined for the previous five fishing seasons, thereby triggering the reference point for a decline over two years (Table 5, Figure 8). In 2013/14 the state-wide catch rate fell by 4.6% from 2012/13 and is currently at about 23% of the 1995/96 catch rates.

Regionally, catch rates in the West have been almost double that of the East over the last three fishing seasons but have both steadily declined since 2009/10. Catch rates in 2013/14 declined by 4.1% in the West and 11.3% in the East from the previous fishing season and are currently at about 27% and 15% of the 1995/96 catch rates respectively.

The catch rate limit reference point (a total decline by 20% over a 2-year period) was not exceeded in any of the regions with declines averaging around 8-9% (Table 5, Figure 8).

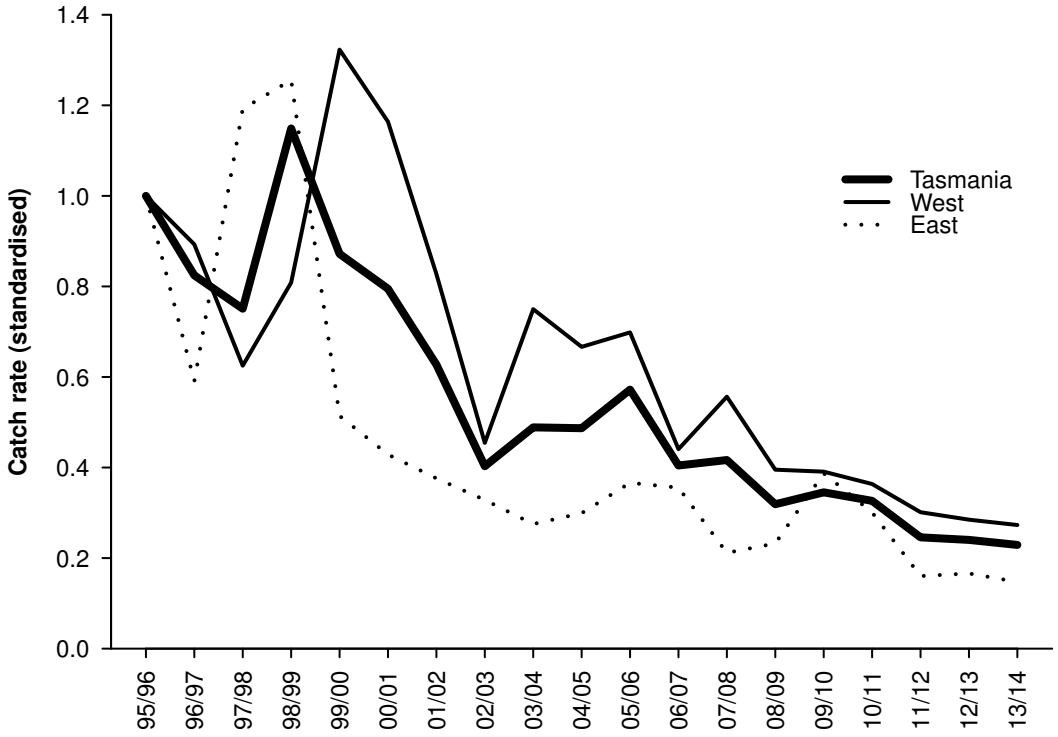

Figure 8: Trends in State-wide annual catch rates (standardised catch rates relative to 1995/96) by quota year, based on a selection of skippers that had reported a median catch of at least 1000 kg over a minimum of 2 years.

Table 5: Targeted State-wide and regional catch rates for the 13/14 quota year relative to catch rates 5, 2 and 1 year ago. The reference point relates to the 2-year period (11/12).

Quota year	Tasmania	West	East
95/96	1.00	1.00	1.00
96/97	0.82	0.89	0.59
97/98	0.75	0.62	1.19
98/99	1.15	0.81	1.26
99/00	0.87	1.32	0.51
00/01	0.79	1.16	0.43
01/02	0.63	0.83	0.38
02/03	0.40	0.45	0.33
03/04	0.49	0.75	0.28
04/05	0.49	0.67	0.30
05/06	0.57	0.70	0.37
06/07	0.40	0.44	0.36
07/08	0.42	0.56	0.21
08/09	0.32	0.40	0.23
09/10	0.35	0.39	0.39
10/11	0.33	0.36	0.30
11/12	0.25	0.30	0.16
12/13	0.24	0.28	0.17
13/14	0.23	0.27	0.15

Change in 13/14 catch rates (in %) compared to:			
08/09	-28%	-31%	-37%
11/12	-7%	-9%	-8%
12/13	-5%	-4%	-11%

4.5 Bycatch of crabs from the lobster fishery

The reference point relating to bycatch of crabs in the lobster fishery is set at 5 tonnes, which represented about 11% of the 2013/14 TAC. Over the last few fishing seasons the bycatch from the fishery has not exceeded 1 tonne and over the last two fishing seasons has been less than 200 kgs (Figure 9). Industry members have previously advised that any reported bycatch in the fishery would probably be an underestimate. Nevertheless, whatever the true level of bycatch it was likely to be small relative to the targeted crab catch.

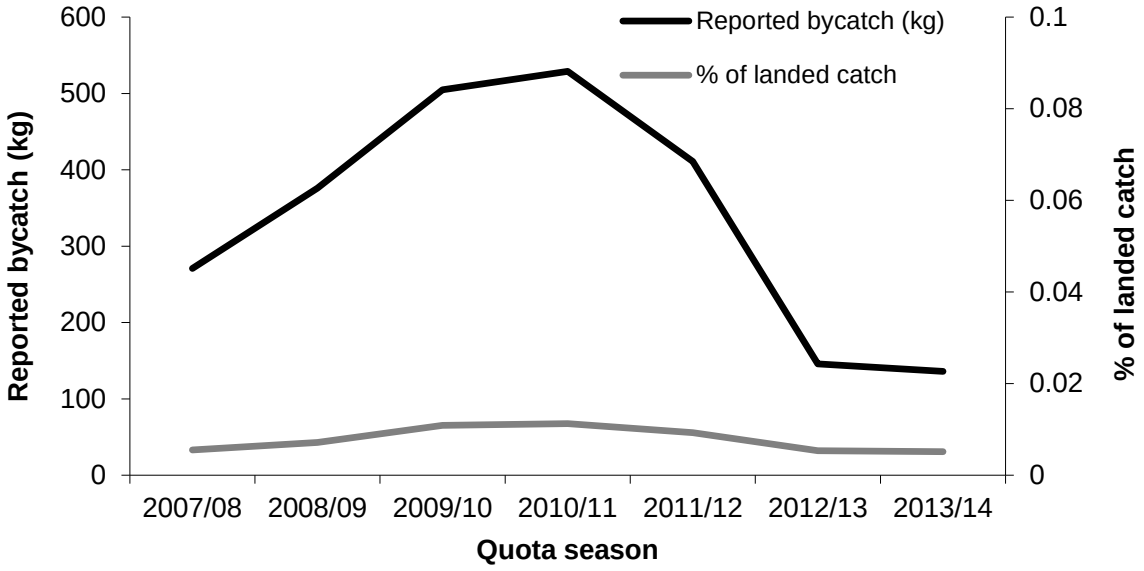

Figure 9: Total reported bycatch of crabs in the rock lobster fishery and percentage of the total giant crab catch.

4.6 Additional information on composition of catches

For each shot, Tasmanian giant crab fishers record the sex composition, the number of undersize returned and the estimated weight. Using accurate weights at landing permits the estimated weights to be corrected. This extensive information allows several important aspects of the catch to be calculated, in particular i) the average weight of retained crabs, ii) the proportion of females in the retained catch and iii) the number of undersized crabs per potlift. This data is shown in Figure 10 for the last decade.

Catch rates of undersize crabs (which are released) provide an indication of undersize abundance, and an indication of the strength of future recruitment. Undersize catch rates have traditionally been lower on the West coast than on the East coast but since 2010/11 this has reversed with large declines in the catch rates of undersize on the East coast and concurrent increases on the West coast. The declining trend on the East coast suggests there will be fewer crabs recruiting into the exploitable biomass in future years, while concurrently on the West coast there should be a greater number of crabs recruiting into the exploitable biomass. Due to the slow inherent growth rate of giant crabs however, there is uncertainty as to how long it will take before these undersize crabs recruit to the exploitable biomass.

On both coasts the average weight of crabs has declined through time as larger crabs were removed and the fishery became more dependent on recruits. The average weight of crabs has increased on the East coast over the last four years however, which is possibly due to the low number of recruits. The average weight on the West Coast has also increased over the past three years.

The sex ratio of catches has been different between coasts with catches from the East strongly biased towards females. Catches in the West have historically been biased towards males, however over the last three fishing seasons the sex ratio has been relatively equal.

Two factors influence trends in undersize catch rates, firstly undersize crabs are not evenly distributed between regions and with depths (see Williams et al. (2009)). Consequently, change in the distribution of fishing effort may influence the trends in undersize catch rates. However this effect is highly unlikely to fully explain the observed consistent trend.

The second factor which will have decreased undersize catch rates is the change in male minimum size limit for 2009/10. The male minimum size limit was reduced (in combination with a cut in the TAC), thereby some crabs that would previously have been classified as undersize became legal sized. Note that the decreasing trend

was evident prior to the change in size limit (in 2008/09).

Large males that were over 215 mm CL were released under rules applied until the end of the 2012/13 season (end of February 2013). Historically this number was below 2% of the catch (by number) on both the West and East coasts. The maximum size limit for males was removed commencing the 2013/14 season because it was determined that only 20% of males in an unfished population would reach this size and the limit could result in a higher proportion of the annual catch being females, which could impact future egg production.

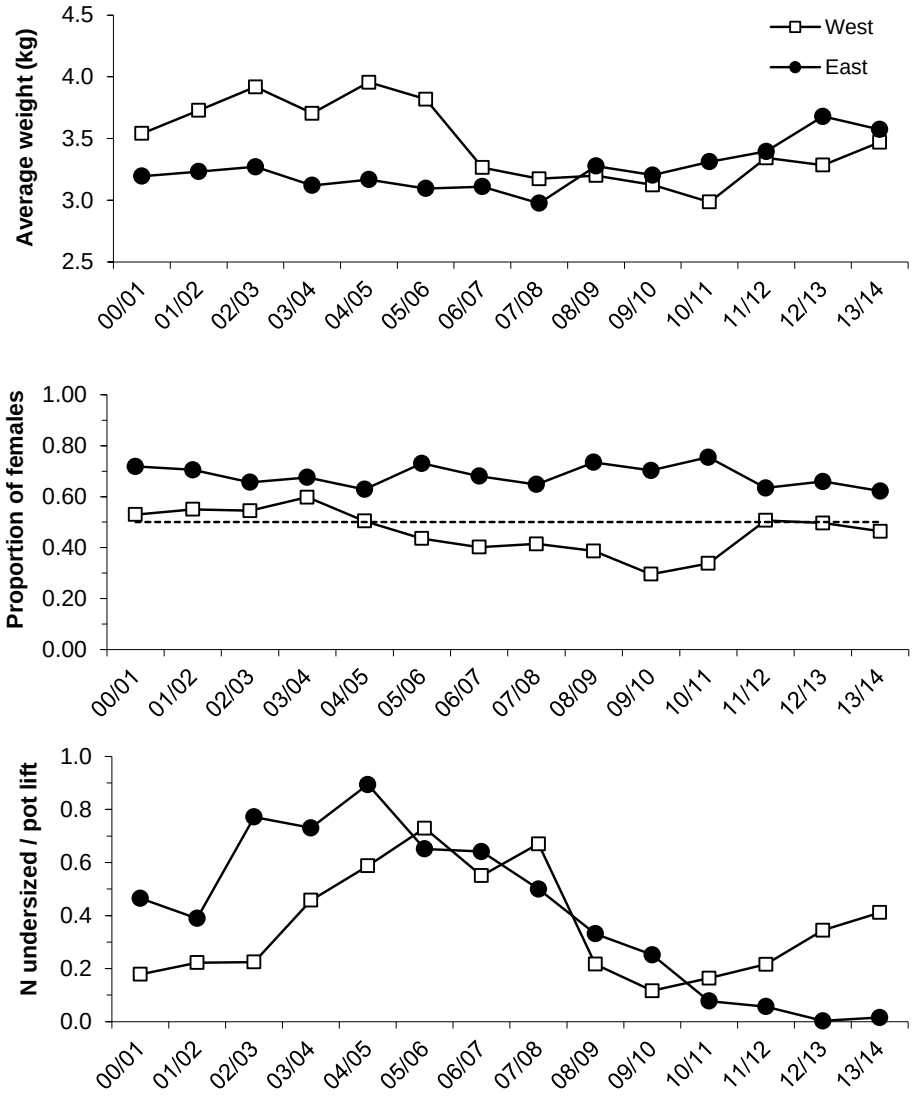

Figure 10: Top: Average weight of retained catch; Middle: the proportion of the retained catch that was female (the dotted line represents 50% or an equal spit between males and females); Bottom: catch rate of released undersize crabs.

4.7 Retained bycatch species

The bycatch taken by the fishery is low compared with other fishing methods. The impact of giant crab fishing on non target species is considered negligible with the most common species caught historically (draughtboard sharks and hermit crabs) being returned to the water alive. Fishers may retain some bycatch species to be used as bait or for personal use. In this instance such details will be recorded in the fishers' log (See Table 6). Fishers are not currently permitted to retain southern rock lobsters while fishing for giant crab.

Table 6: Reported **retained** Tasmanian giant crab fishery bycatch.

Species	11/12 (kg)	12/13 (kg)	13/14 (kg)
Crab unspecified	0	0	20
Conger Eel	0	0	9
Ling	26	76	0
Morwong	22	44	12
Octopus unspecified	0	0	1
Striped Trumpeter	0	3	10

4.8 Endangered, threatened and protected species interactions

Endangered, threatened and protected species interactions are now recorded directly in the giant crab logbook. No interactions were reported by fishers targeting crabs in 2013/14 and none in fact have been recorded in any research or observer sampling on board commercial vessels in the history of the fishery. This would be expected given that the fishery operates in deep water away from coastal areas frequented by juvenile seals and cormorants, which interact with traps in the lobster fishery.

5 Stock Assessment Modelling

5.1 Introduction

A length-based stock assessment model for the Tasmanian giant crab fishery was introduced in Ziegler et al. (2009). In this assessment the same model has been used in conjunction with the new data available (new catch records and industry collected length frequency data). The model was applied to pooled data from the Western and Eastern side of the continental shelf ('Tasmania'), and to the data from the two fishing regions independently ('West' and 'East').

The results for the whole state allow the state of the entire fishery to be considered whilst the results for the two areas ('West' and 'East') permit spatial trends to be monitored. Current management arrangements such as TAC and size limits apply to the whole Tasmanian fishery, nevertheless considering the areas individually will highlight any spatial concerns and subsequent need for spatial management.

5.2 Current status

Figures 11 and 12 show catch and model estimates of egg production, exploitable biomass, total biomass, catch rates and harvest rates State-wide and for the East and West regions. The State-wide the biomass has been substantially reduced since the commencement of the fishery and is now at 9% of the 1992 value.

The following trends were observed since the last stock assessment. The exploitable biomass has continued to decline across all three spatial scales, despite the reduction in the minimum size limit for the 2009/2010 fishing season, a further reduction in the TACC in 2012/13 to 46.6 tonnes and substantial under-catches in 2012/13 and 2013/14. The total biomass has continued to trend downwards across all three spatial scales as well, however egg production appears to have stablised State-wide and in the West over the last three fishing seasons. The modelled harvest rate has also continued to decline but over the last two fishing seasons has remained stable State-wide and in the West. Both the exploitable biomass and modelled harvest rates have continued to decline in the East.

It is important to note that recent size estimates used in the stock assessment model and displayed in Figures 13 and 14 are based entirely on commercial length-frequency data collection which is primarily collected by a single operator. This introduces a potential bias in the model due to the effect of fisher behaviour on giant crab size. DPIPWE is currently working with giant crab operators to attain additional size estimates.

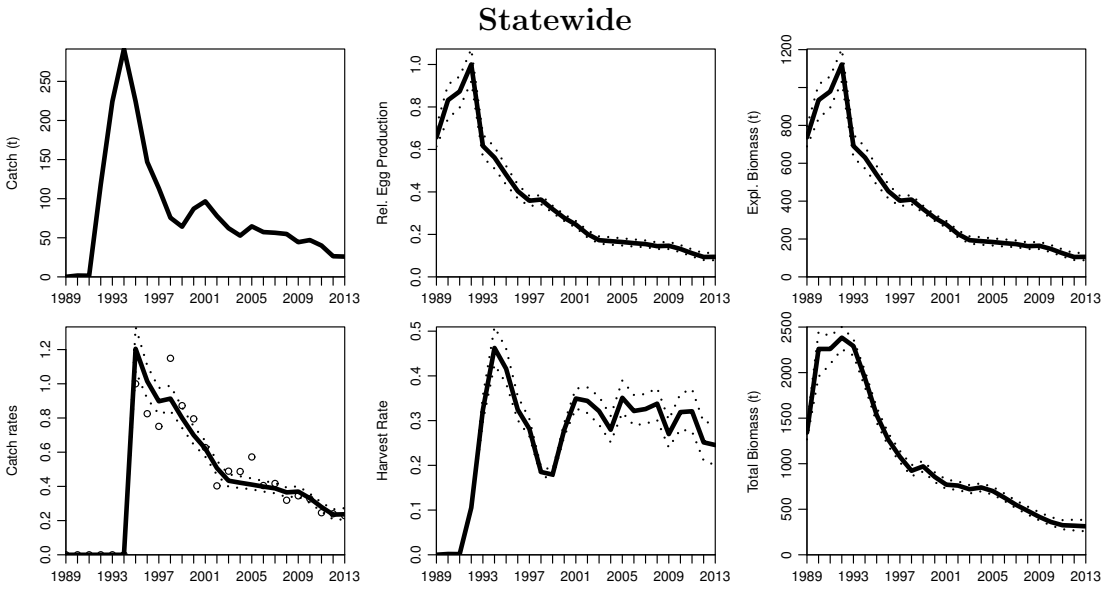

Figure 11: State-wide results of the model fitted to the observed data since 1989/90 (first year of quota year given). Observed catch, observed standardised (black dots) and fitted predicted catch rates (line), relative egg production, estimated annual harvest rates, total biomass and exploitable biomass at the start of each quota year. Median values (heavy lines) and 90% confidence intervals (light lines) from the bootstrap procedure given.

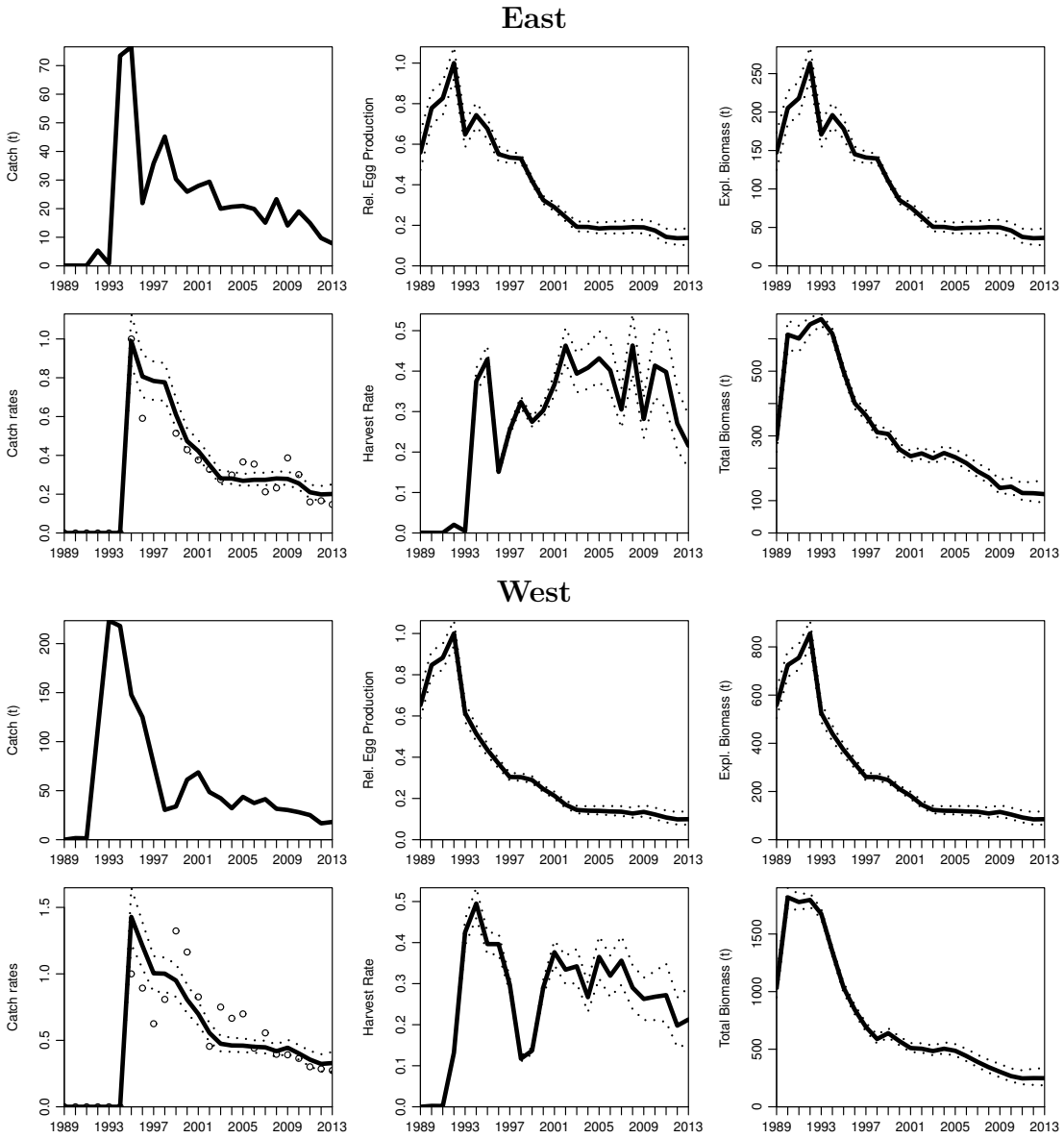

Figure 12: (continued) East (top panel) and West (bottom panel) results of the model fitted to the observed data since 1989/90 (first year of quota year given). Observed catch, observed standardised (black dots) and fitted predicted catch rates (line), relative egg production, estimated annual harvest rates, total biomass and exploitable biomass at the start of each quota year. Median values (heavy lines) and 90% confidence intervals (light lines) from the bootstrap procedure given.

Table 7: Summary of model estimates for exploitable biomass, harvest rates and egg production. The median is given with the 90% confidence interval in brackets below).

	Exploitable biomass			Harvest rate	Total bio.	Egg prod.
	Virgin (t)	2013 (t)	% Virgin	In 2013	% Virgin	% Virgin
State	1122	106	9	25	13	14
	(1032-1203)	(88-130)	(8-12)	(20-30)	(11-16)	(12-17)
West	856	85	10	21	14	14
	(804-909)	(62-119)	(8-13)	(15-29)	(10-18)	(10-19)
East	264	36	14	22	18	20
	(243-285)	(27-49)	(11-18)	(16-29)	(14-24)	(16-25)

5.2.1 Virgin biomass

The current giant crab model provides a good fit after the initial high catches in the early 1990s. However the recruitment estimated for this period (beyond the early 1990s) is insufficient to account for the biomass that existed prior to the commencement of the fishery. Consequently, the model produces the initial biomass through a series of strong recruitment events in the first four years (1989-1992) this is evident in Figure 11 which shows a strong growth in biomass prior to the full scale commencement of the fishery.

The initial strong recruitment events are likely to be model artefacts, resulting from the model inadequately capturing the difference between the relatively fished and unfished stock. Possible explanations are:

- A genuine change in recruitment – For example, the model does not include a stock-recruitment relationship and consequently average recruitment to the fished stock is assumed to be at the same level as average recruitment to the unfished stock.
- A misspecification of crab growth and mortality at old age – the understanding of giant crab growth and survival at old ages is poor. Since the fished population has far fewer old aged crabs, this will have much greater impact on the dynamics of the stock in the early stages of the fishery. To compensate for this mis-specification the model has needed to introduce some initial anomalously high recruitment events.

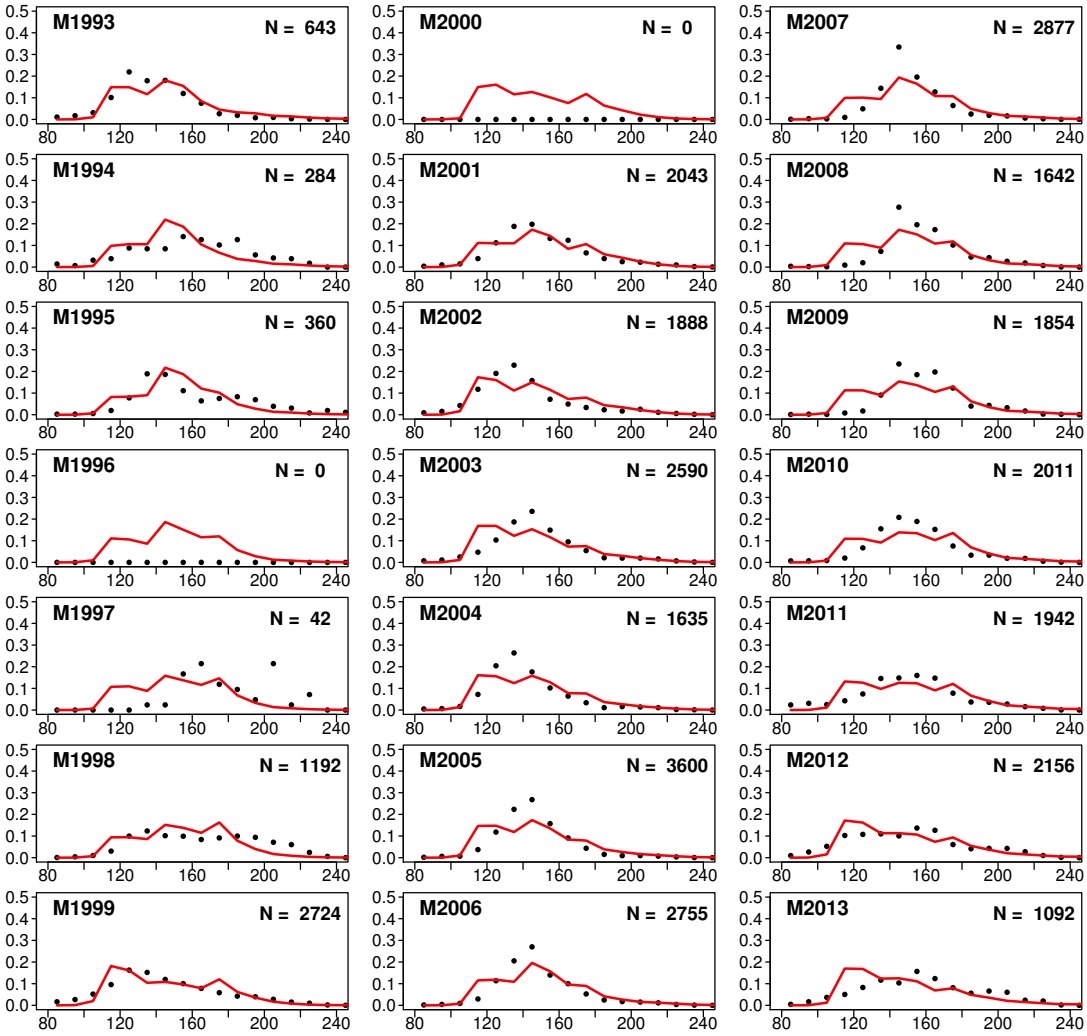

Figure 13: Observed (points) and predicted (lines) length frequencies in State-wide commercial catches since 1993/94 (M1993) for male giant crab with the observed sample sizes N

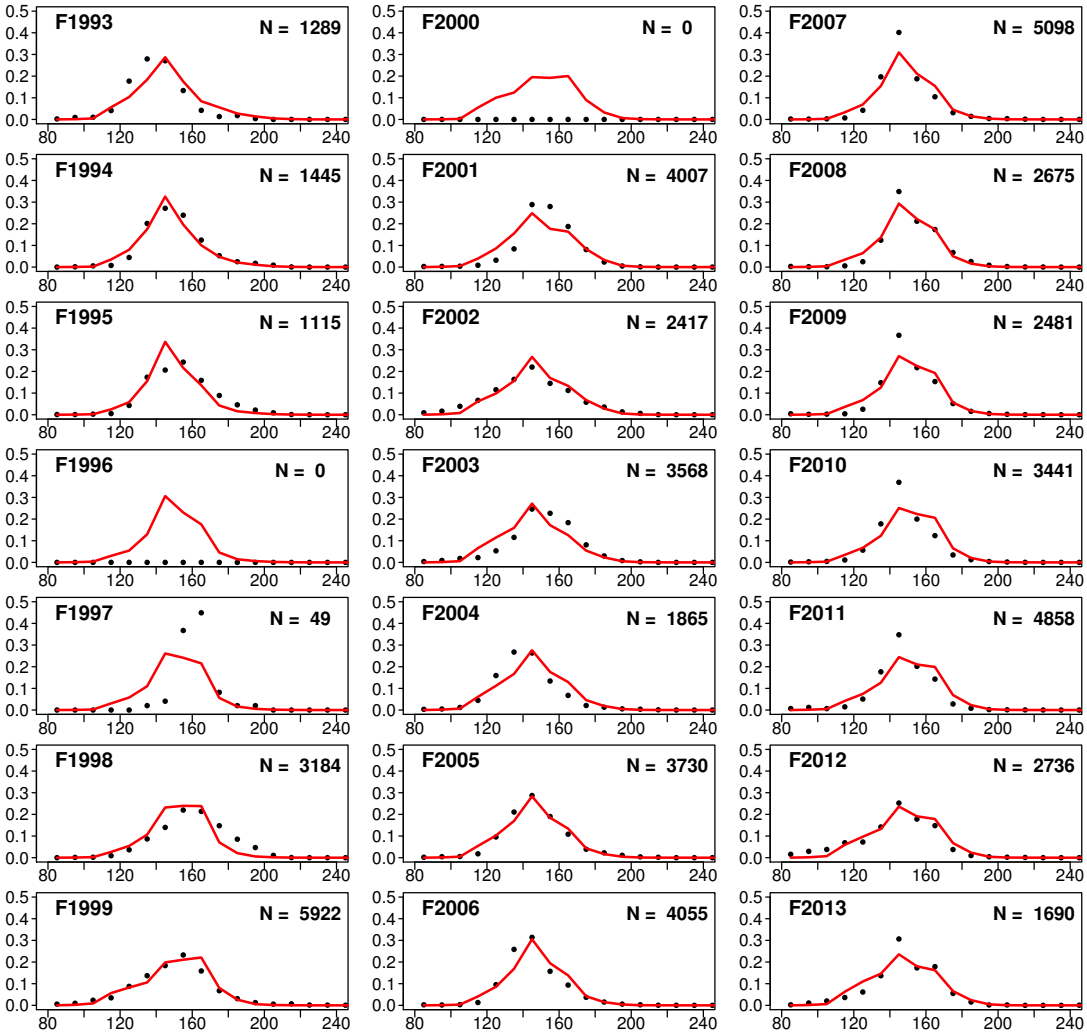

Figure 14: Observed (points) and predicted (lines) length frequencies in State-wide commercial catches since 1993/94 (F1993) for female giant crab with the observed sample sizes N

Recruitment estimates from the mid 90s onwards are consistent and the model is appropriate for the fish stock in its exploited state. However, this problem complicates the estimation of virgin biomass (a current reference point for fisheries management). In particular, the virgin biomass corresponding to current recruitment estimates is significantly less than the biomass estimate prior to commencement of the fishery. Furthermore, the model estimates of peak biomass for the fishery in the current assessment are much lower than the previous assessments but despite this change the underlying trends are similar. However due to the large initial catches and slow growth of giant crabs, the virgin biomass may be underestimated by this method.

5.3 Projections

The giant crab model can be used to examine the future outcomes of the fishery by taking the historic recruitment estimates and projecting the fishery forward with these recruitment estimates. As discussed previously, recruitment estimates for the first few years are anomalous, consequently recruitment estimates from 1993 onwards were utilised. Figure 15 provides detailed model projections for a State-wide catch of 34.3 tonnes, with 12 tonnes caught in the East and 22.3 tonnes in the West. This represents a 10% undercatch of the current TACC (38.3t) and a 35% - 65% division of catches East-West, which is within historical ranges. These figures show the median value, a 90% confidence limit and the 20th percentile.

The 20th percentile and lower confidence limit are useful measures for cautionary management – if the aim is to keep the fishery above eg. a certain catch rate, then a cautionary approach might choose a TACC that keeps the 20th percentile above this value or more cautiously, the lower confidence limit.(Figure 15)

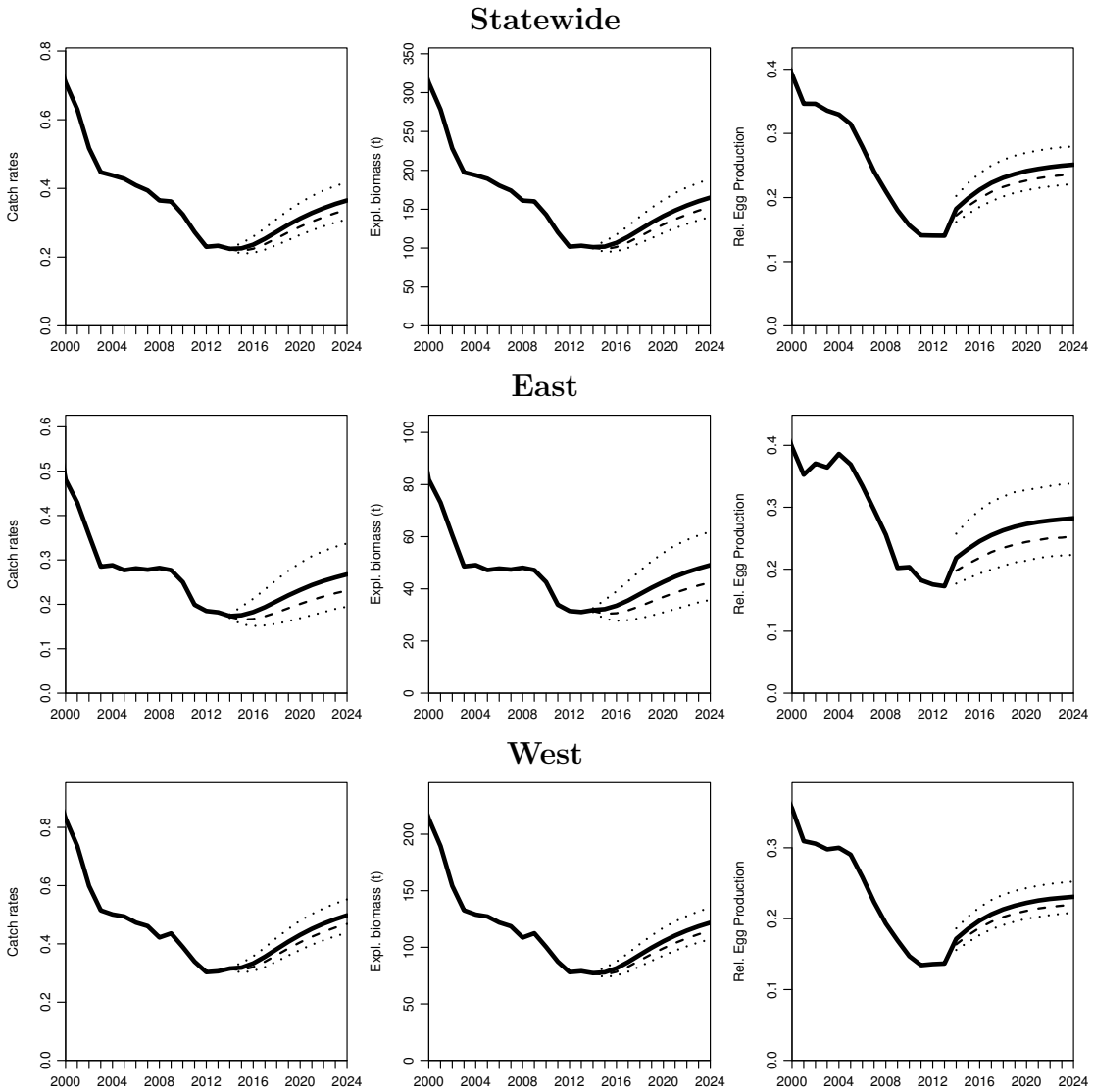

Figure 15: State-wide (top panel), East (center panel) and West (bottom panel) model projections under a 38.3 tonne TACC with 10% undercatch (12t East and 22.3t in West). The solid line shows the median, the dotted line is the 90% confidence limit and the dashed line is the 20th percentile

Table 8: Five and ten year model projections (increase or decrease) for State-wide, East and West coast total biomass, egg production and catch rate relative to the current fishing season.

Indicator	In 5 years time	In 10 years time
State-wide		
Exploitable biomass	20%	56%
Egg production	64%	78%
Catch rate	17%	52%
East coast		
Exploitable biomass	22%	54%
Egg production	56%	64%
Catch rate	21%	47%
West coast		
Exploitable biomass	18%	50%
Egg production	36%	68%
Catch rate	25%	58%

5.4 Modeling conclusions

The giant crab model provides a good fit to the fishery after the initial high catches. This makes it well suited to tracking recent changes in the fishery and projecting the future performance of the fishery under different management options. The model does not adequately explain the high biomass present prior to the commencement of the fishery. Consequently, the peak biomass predicted by the model and the estimate of virgin biomass has varied across assessments and may be underestimated. Note that if this is the case the reference points based on this level should actually be slightly higher. Further discussion on suitable reference points are required that take into account the current state of the fishery and the slow growth of the stock.

The model shows similar trends statewide and regionally in the West and East with the exception of egg production. Exploitable biomass has continued to decline, as have catch rates but egg production has stablised State-wide and started to increase in the West. Egg production on the East coast has continued to decline and the length frequency and catch rate plots indicate there is a concerning underabundance of undersize giant crabs. Fishers have also noted the concerning lack of undersize giant crabs on the East coast over the last few seasons.

With a 10% undercatch of the new 38.3 tonne TACC (i.e. 34.3 t) split 12 tonnes

in the East and 22.3 tonnes in the West the State-wide exploitable biomass is expected to rebuild to 56% greater than present levels in 2023. On the East and West coasts the exploitable biomass is expected to rebuild to 54% and 50% greater than present levels in 2023. State-wide egg production is also expected to increase to 78% greater than present levels in 2023 and catch rates are expected to be 52% greater than present levels in 2023. These projections are all positive signs for the industry and real trends may be higher if TACC continues to be under caught substantially as has occurred in the last two fishing seasons.

The extent of the ongoing decline in CPUE in 2011/12 and 2012/13 was not predicted by the previous stock assessment despite actual catches being substantially lower than those that were modelled. This raises concern that the observed CPUE declines are due to external factors not modelled and that the positive model based outlook should be treated cautiously.

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