



Department of
**Primary Industries and
Regional Development**

Fisheries Management Paper No. 288

**Protecting breeding stock
levels of the blue swimmer crab
resource in the south west**

A review of management arrangements

October 2018

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ISSN: ISSN 0819-4327

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1.0 INTRODUCTION	1
2.0 CRAB FISHERIES OF THE SOUTH WEST	3
2.1 Commercial Fisheries.....	3
2.2 Recreational Fisheries.....	4
2.3 Current Rules for Crab Fisheries of the South West.....	4
3.0 STOCK STATUS AND CATCH TRENDS OF SOUTH WEST BLUE SWIMMER CRAB FISHERIES.....	6
4.0 BACKGROUND BIOLOGY OF BLUE SWIMMER CRABS IN THE SOUTH WEST.....	10
5.0 WHAT HAS CHANGED AND WHY DO FEMALE CRABS NEED MORE PROTECTION?.....	13
5.1 Commercial Fisheries.....	13
5.2 Recreational Fisheries.....	14
5.3 Overall.....	15
6.0 MANAGEMENT OPTIONS FOR INCREASING PROTECTION OF THE BREEDING STOCK.....	16
6.1 Options for increasing protection of the breeding stock	16
6.2 Evaluating the management options.....	16
6.3 Summary of the options	22
7.0 POSSIBLE IMPROVEMENTS TO THE OVERALL MANAGEMENT FRAMEWORK FOR THE FISHERY	26
8.0 CONCLUSION	30
Appendix 1	31
Appendix 1.1	32
Appendix 1.2	34
Appendix 1.3	38

FIGURES

Figure 1.	Geographic distribution of the blue swimmer crab, <i>Portunus armatus</i> in Australian waters.....	1
Figure 2.	Key crab fishery areas in the South West	2
Figure 3.	Catch of blue swimmer crabs by commercial fisheries in the West Coast Bioregion 1995 - 2017.	6
Figure 4.	A typical spawning stock - recruitment relationship with three levels of environmental conditions indicated.	12
Figure 5.	Seasonal distribution of start locations of trap lines in the Peel-Harvey Estuary in summer and winter (2011 to 2016).....	20
Figure 6.	Seasonality and average percentage of annually detected offences by recreational crab fishers in the Peel-Harvey Estuary, (■) Peel Harvey Estuary Undersize and (■) Other Peel Harvey Estuary Recreational-Crabbing Offences. Data is presented by calendar year from 2012 to 2016.	27

TABLES

Table 1.	Commercial blue swimmer crab fisheries of the West Coast Bioregion.	3
Table 2.	Fishing Rules (Seasons and Size limits) in the various commercial and recreational crab fisheries in the South West.....	5
Table 3	Recreational Survey Results (95% CIs where lower/upper estimates are shown). 8	
Table 4.	Mean monthly percentage of females in the landed catch of the various commercial fisheries over various time periods between 2007 – 2015. Months with >50% female crabs in the catch are highlighted in yellow.	14
Table 5.	Summary of Breeding Stock Management Options.	25

EXECUTIVE SUMMARY

The closure of the Cockburn Sound Crab Fishery in 2006 and again in 2014, coupled with the broadly declining catches of the blue swimmer crab fisheries in the South West of the State, has called into question the resilience of the blue swimmer crab breeding stock and highlighted the need for a review of the South West blue swimmer crab resource. The focus of the review is on management options to improve the robustness of blue swimmer crab stock by increasing the level of protection of the breeding stock.

The Discussion Paper identifies that the existing management arrangements do not adequately address the protection of the breeding stock across the resource because they have been developed at the scale of local estuaries and embayments. In particular, the arrangements are not achieving appropriate levels of protection for mated, pre-spawned females, which become highly vulnerable to capture in late autumn, winter and spring.

The paper examines and compares options for new, broader-scale, management arrangements that move away from the current local-level arrangements and provide co-ordinated protection for the female breeding stock across the linked populations that form the resource.

The scope of the review and options set out in this Discussion Paper encompass commercial and recreational fishing within the waters of the West Coast Estuarine Fishery (the Swan-Canning and Peel-Harvey Estuaries), the Cockburn Sound Crab Fishery, the Warnbro Sound Crab Fishery, the Mandurah to Bunbury Developing Crab Fishery (Comet Bay and Mandurah to Bunbury) and the recreational-only fisheries of the Leschenault Estuary and Geographe Bay.

Importantly, the review is **not** about the catch shares of each of the sectors. Rather, the review is about how the activities of each sector, which are legally-permitted by the current arrangements, impact on the abundance of the breeding stock – and in particular the abundance of female crabs. Nevertheless, any changes to the management arrangements arising as a result of the review are likely to have consequential impacts on catches in particular commercial fisheries and generally across the recreational sector.

The options and key considerations are summarised in the table below. In weighing-up the options, the Discussion Paper considers impacts on the economics of commercial fishers and the recreational fisher experience, compliance costs, the amount of handling and discard of crabs, and whether or not the option increases or decreases the overall level of management complexity for the blue swimmer crab resource.

While each option has particular pros and cons, the Discussion Paper identifies broad-scale seasonal closures as the most balanced option. The paper also looks at other outcomes that could be encouraged through a change in the fishing rules, such as a reduction in undersize crab offences by recreational fishers

People are encouraged to read the entire Discussion Paper to get a full understanding of the issue and relevant information to inform their thinking and comments on the options.

Summary of Breeding Stock Management Options:

Option No.	Nature of option	Compliance cost	Impacts on commercial viability	Outcomes for recreational fisher experience	Handling and Discard	Improves consistency of rules
1	Male only	High	Daily – Yes Annual - Yes	Reduced	Increased	Doesn't improve current seasonal closure inconsistencies. Adds an extra rule and may add seasonal inconsistency if only applied seasonally at the time of high female catchability.
2	Increase Minimum Legal Size	High (initially)	Daily – Yes Annual – Yes (Note: impact may vary where commercial fisheries already fishing at a higher size limit).	Reduced	Increased	Doesn't improve current seasonal closure inconsistencies. Only consistent if applied for the whole season and to both sexes. Otherwise adds a seasonal or sex inconsistency.
3	Limiting the ability to catch female crabs at times when they are more vulnerable to capture	Commercial: Moderate Rec: High	Daily -Yes (But gear entitlement transfers may assist) Annual - Yes	Reduced	Reduced	Doesn't improve current seasonal closure inconsistencies. Adds a seasonally-varying gear usage (commercial) or bag/boat limit (recreational) inconsistency.
4	Patchwork seasonal closures	Moderate	Daily – No (but areas that are open will likely be lower catch ae areas) Annual - Yes	Reduced in areas that are open as they will likely be lower catch rate areas.	Reduced	Doesn't improve current seasonal closure inconsistencies. Adds a patchwork of temporally-closed areas.
5	Broad-scale seasonal closures	Low	Daily – No (at times when the season is open) Annual - Yes	Same or Increased (at times when the fishery is open), reduced when fishery is closed.	Reduced	Removes current seasonal closure inconsistencies.

OPPORTUNITY FOR COMMENT

Comments on the Discussion Paper are sought from all stakeholders, including commercial and recreational fishers, relevant community interest groups, Government agencies and interested members of the public.

Once public comments have been considered, the Minister for Fisheries will consider feedback and make decisions on appropriate management arrangements for the South West blue swimmer crab resource.

Although specific issues have been identified, your views are sought on any or all of the matters in this Discussion Paper of significance to you and/or your group.

To ensure your submission is as effective as possible, please:

- make it clear and concise;
- list your points according to the topic sections and page numbers in this Discussion Paper;
- state whether you agree or disagree with any or all of the information within each topic, or on matters of specific interest to you. Clearly state your reasons, particularly if you disagree and give sources of information where possible; and
- outline any alternative suggestions that take into consideration the issues.

Your comments should be submitted by 4pm on 23 November 2018 and should be addressed to:

The Director Aquatic Resource Management

Attention: Crab Management Officer

Department of Primary Industries and Regional Development

Locked Bag 39

Cloisters Square WA 6850

Or by email to:

crab.review@dpird.wa.gov.au

The peak representative bodies (Recfishwest and WAFIC) will be making submissions to this Discussion Paper. To assist these bodies you may wish to forward a copy of your submission to info@recfishwest.org.au or reception@wafic.org.au.

1.0 INTRODUCTION

The blue swimmer (or blue manna) crab (*Portunus armatus*) occurs in the tropical waters of northern Australia and east to New Caledonia. Along the Australian coast it extends into the temperate waters of both the east and west coasts. An isolated stock is found in the warmer waters of the South Australian gulfs and adjacent coast (Figure 1).

In Western Australia the species is near to the southern end of its range in the waters of the South West (Perth to Augusta). Small populations exist in some of the estuaries of the south coast and adjacent waters.



Figure 1. Geographic distribution of the blue swimmer crab, *Portunus armatus* in Australian waters

Within the West Coast Bioregion (essentially Kalbarri to Augusta), the blue swimmer crab resource supports socially and economically important recreational and commercial fishing activities, principally in the South West (Figure 2). In the South West, crab stocks are normally most abundant in marine embayments and estuaries, although stock levels in the estuaries fluctuate seasonally. Crabs move into estuaries in late spring/summer as the salinity increases and back into coastal waters as the salinity in the estuaries decreases with winter rainfall.

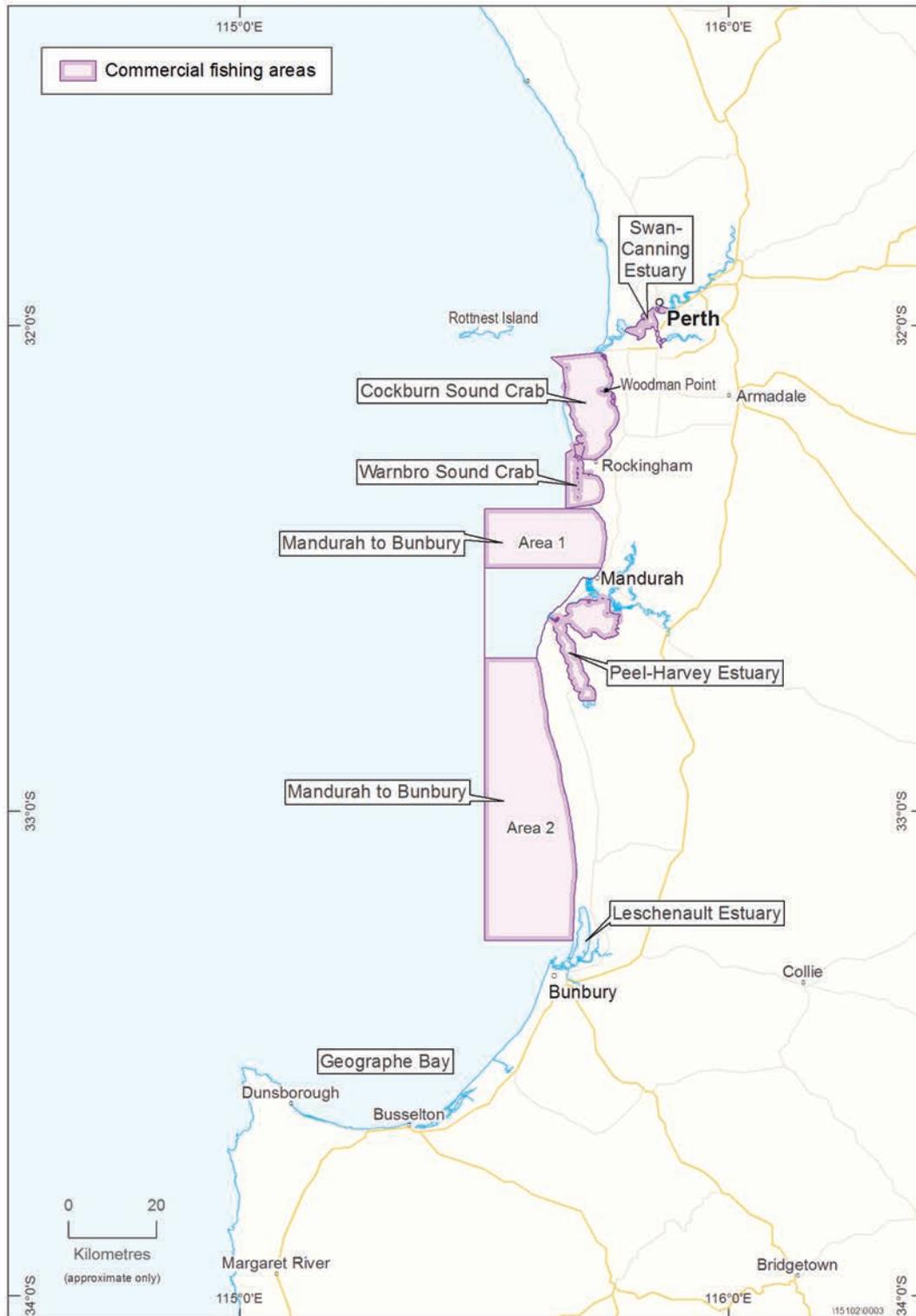


Figure 2. Key crab fishery areas in the South West

Note: Recreational fishing occurs right across the South West, both inside and outside the commercial fishing areas indicated.

2.0 CRAB FISHERIES OF THE SOUTH WEST

2.1 Commercial Fisheries

There a number of commercial fisheries authorised to fish for blue swimmer crabs in estuarine, embayment and coastal waters of the West Coast Bioregion (Table 1). The locations of these fisheries are shown in Figure 2.

Table 1. Commercial blue swimmer crab fisheries of the West Coast Bioregion.

Water body type	Fishery	No operators	Gear used
Marine embayment	Cockburn Sound Crab Managed Fishery	12	Traps (640)
	Warnbro Sound Crab Managed Fishery	1	Traps (100)
Coastal marine	Mandurah to Bunbury Developmental Crab Fishery (Area 1) [Comet Bay]	1	Traps (80)
	Mandurah to Bunbury Developmental Crab Fishery (Area 2) [Cape Bouvard to Bunbury]	1	Traps (120)
	Swan River Estuarine Fishery (Area 1; West Coast Estuarine Managed Fishery)	1	Nets Max 500m per day
Estuarine	Peel-Harvey Estuarine Fishery (Area 2; West Coast Estuarine Managed Fishery)	10	Traps (420)

In the period 2010 - 2013 these fisheries collectively took approximately 150 – 200 tonnes of crabs a year. Recently, however, commercial crab catches in the South West have declined to around 80 tonnes.

The Peel-Harvey Estuary fishery is currently the largest of the commercial crab fisheries in the South West. In the 2012 – 2015 period this fishery took an annual catch of around 100 tonnes, increasing from around 50 – 60 tonnes in the late 1990s/early 2000s. Recently the annual catch has declined to around 50 tonnes.

The Cockburn Sound Crab fishery was the largest commercial crab fishery in the South West during the mid-to-late 1990s, when it took annual catches of around 300 tonnes. However, stock levels declined significantly in 2006 and the fishery was closed for 3 years to allow

stocks to rebuild. When it re-opened in 2009 (and prior to a second significant stock decline and closure in 2014), annual catches were around the 50 tonne level.

The remaining approximately 10 - 30 tonnes of annual commercial catch comes variously from the Swan-Canning Estuary, Warnbro Sound and the Mandurah to Bunbury Developmental Crab fisheries. A trawl operator who took crabs as part of mixed trawl fishery in the Comet Bay area (near Mandurah) left the industry in 2014 under a Voluntary Fisheries Adjustment Scheme.

2.2 Recreational Fisheries

The Perth to Busselton area of the West Coast Bioregion is home to the State's very popular recreational crab fisheries. In the 2011/12 and 2013/14 recreational fishing surveys utilising the Recreational Fishing from Boat Licence (RFBL) data, blue swimmer crabs were the most numerous species retained by boat-based recreational fishers - both statewide and in the West Coast Bioregion (WCB)¹. In the 2015/16 RFBL survey, however, the most numerous retained species was western rock lobster (both statewide and in the WCB). Nevertheless, blue swimmer crabs were the second-most retained species, both statewide and in the WCB. The retained catch in the WCB in the 15/16 survey of over 180,000 crabs was 92% of the statewide catch, with an estimated landed weight for the Bioregion of 43t (95% confidence intervals: 36 – 50t) taken by boat based fishers.

The bulk of the retained catch by boat-based fishers (82% of the statewide catch in the 15/16 survey) is taken in the Metropolitan Zone of the WCB (i.e. waters between 31° and 33° south – Lancelin to Cape Bouvard), with an average of 76% being taken in the Zone over the three surveys (11/12, 13/14 and 15/16). The Metropolitan Zone encompasses the key crab fishing areas of the Swan-Canning Estuary, Cockburn Sound, Warnbro Sound and the Peel-Harvey Estuary. A further 10% of the 15/16 statewide catch of blue swimmer crabs (and an average of 13% over the three surveys 11/12, 13/14 and 15/16) was taken in the South West Zone (defined in the surveys as Cape Bouvard to just east of Augusta), which encompasses the waters of Leshenault Estuary and Geographe Bay, as well as Hardy Inlet.

Crabs are also taken by shore-based recreational fishers using scoop nets and drop-nets (from jetties, bridges and the shore) as well as by hand by recreational divers operating from the shore. This component of the catch is not measured by the RFBL surveys. However, surveys of the Peel-Harvey Estuary recreational crab fishery in the late 1990s and again in the late 2000s estimated that shore-based fishers took about 30% of the total recreational crab catch from the Peel-Harvey Estuary.

2.3 Current Rules for Crab Fisheries of the South West

The current set of rules for blue swimmer crab fisheries in the South West in terms of seasons and size limits (Table 2) have developed over time and in response to various circumstances. The 127mm statewide size limit represents a size at which crabs are sexually mature - with females becoming sexual mature at around 80 - 100mm carapace width (CW) in the South West. The higher (130mm) size limit for Cockburn Sound commercial fishers reflects both a marketing strategy around larger crabs and a choice by commercial fishers to avoid competing with recreational fishers for crabs in the 127 – 129mm size range.

The rules (or, in some cases, the lack of them) related to fishing seasons have been developed around local patterns of crab catchability/availability and/or the perceived need for protection

¹ The retained catch of Whiting in the West Coast Bioregion in the 2013/14 survey was slightly higher than the retained catch of Blue Swimmer Crab, but the Whiting category consists of three species.

of the local breeding stock. The perceived need for protection of local stocks has been based on the premise that the various stocks are not physically linked and that they are reproductively independent. However, the current understanding of the nature of the South West crab resource points to some physical linkages between stocks (i.e. crabs migrating into/out of estuaries from coastal areas and between coastal areas) as well as reproductive linkages between populations – at least in the lower South West coastal and estuarine fisheries (Cockburn Sound appears to be somewhat more reproductively isolated) [see later section on Background Biology].

The view of fisheries researchers and managers is that the current ‘piecemeal’ approach to blue swimmer crab management in the South West is not adequately protecting the breeding stock of the South West blue swimmer crab resource. In particular, the current rules do not properly recognise the seasonal vulnerability of females to capture or the need to protect mated, pre-spawn females as well as berried females.

This view was presented by the Department at the Third National Workshop on Blue Swimmer Crab *Portunus armatus* held in June 2015 at the Western Australian Fisheries and Marine Research Laboratories.

Table 2. Fishing Rules (Seasons and Size limits) in the various commercial and recreational crab fisheries in the South West.

Fishing Area	Commercial Closure	Recreational Closure	Minimum Legal Size (mm carapace width ²)
Swan - Canning Estuary	Nil	Nil	127 (both sectors)
Cockburn Sound *currently closed	Mid - June to Mid - December (prior to current Total Fishery closure)	September to Mid – December (prior to current Partial closure – South of Woodman Point)	130 (commercial) 127 (recreational)
Peel - Harvey Estuary	September -October	September -October	127 (both sectors)
Warnbro Sound	October - November	Nil	127 (both sectors)
Coastal areas Becher Pt (Port Kennedy) to Bunbury (Includes Mandurah to Bunbury Developmental Crab Fishery Areas 1 & 2)	Nil	Nil	128 (commercial) 127 (recreational)
Geographe Bay	Closed to commercial fishing	Nil	127 (recreational)
Leschenault Estuary	Closed to commercial fishing	Nil	127 (recreational)

² Carapace width measured from tip to tip of the carapace spikes

3.0 STOCK STATUS AND CATCH TRENDS OF SOUTH WEST BLUE SWIMMER CRAB FISHERIES

Over the last decade, stocks of blue swimmer crabs in the South West have shown a number of signs that recruitment (i.e. juvenile crabs entering the population) may be limited, or at risk of being limited, by the level of abundance of the breeding stock, particularly when low breeding stock levels are combined with unfavourable environmental conditions. This may in part be due to the fact that the crab population in the South West is near the limit of the natural distribution and environmental tolerances of the species, making it particularly susceptible to environmental effects on recruitment. The crab stock in Cockburn Sound is a case in point, having twice declined significantly - once in 2006 and again in 2014. Currently the stock in Cockburn Sound remains low and the area is closed to crab fishing³.

More generally, the overall commercial catch of blue swimmer crabs in the West Coast Bioregion (in effect, the South West) has shown a general decline from peaks of around 400 – 500 tonnes in the mid-to-late 1990s to under 100 tonnes by 2017 (Figure 3). In addition to the significant stock decline in Cockburn Sound, commercial crab catches in Warnbro Sound, the Swan River and the Mandurah to Bunbury crab fisheries have all declined in recent years. The catch in the Peel-Harvey Estuary, while increasing slightly in 2017, is still below the levels of 2012 – 2015.

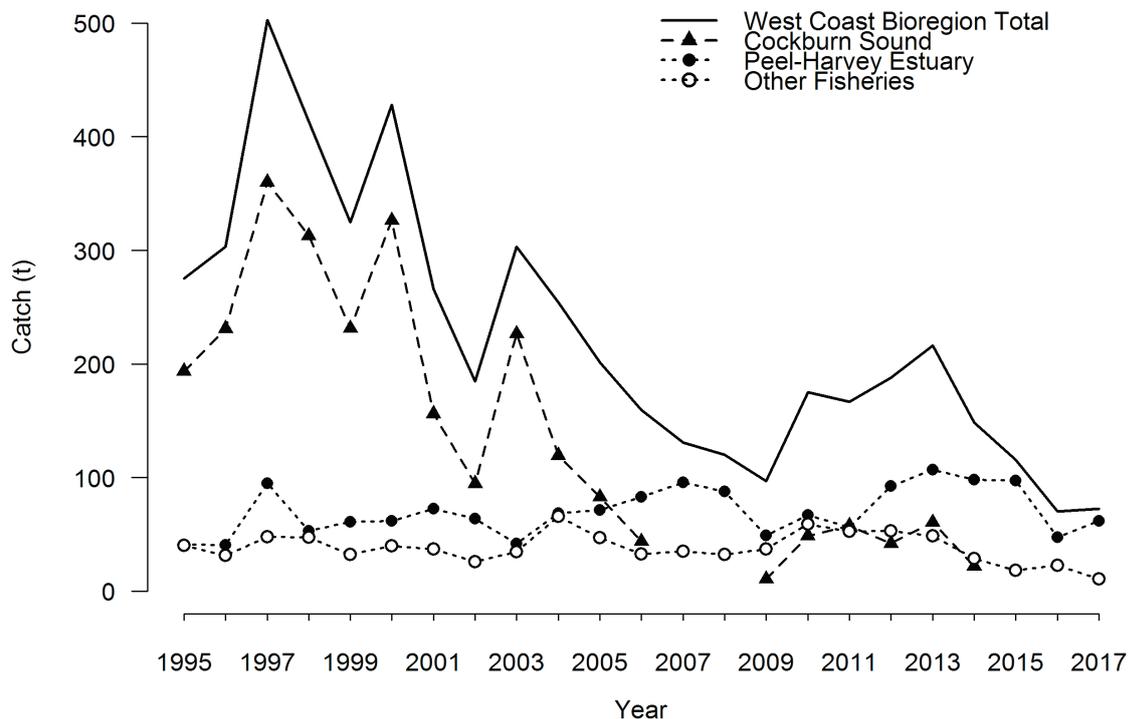


Figure 3. Catch of blue swimmer crabs by commercial fisheries in the West Coast Bioregion 1995 - 2017.

³ For recreational fishers, the Cockburn Sound fishery area is only closed south a line Woodman Pt to Carnac I.

It is more difficult to present a comprehensive picture of changes in recreational crab catches over time because recreational data is only available from various occasional surveys. These surveys have generally been of a particular water body (e.g. Peel-Harvey Estuary, Cockburn Sound) and over a limited time-frame (e.g. 12 months). In essence, these surveys are ‘snapshots’ of crab catches in particular water bodies at a particular point in time.

Methods used in the surveys have also varied, so that surveys conducted for the same water body over time are not always directly comparable because of the different methodologies (e.g. period of the day sampled, types of fishers sampled).

The other issue with these ‘snapshot’ surveys, particularly for short-lived, variable-recruitment species like crabs, is that the survey may have been conducted in a period of good or poor recruitment. Thus, the data may reflect a short-term change in catches arising from this recruitment variation and present an incomplete picture of the long-term trend.

Since the introduction of the Recreational Fishing from Boat Licence (RFBL) in 2010 there has been a standardised approach to collecting recreational fishing data for fishers operating from boats. Because of the standardised methodology of these surveys the catch results over time for boat-based fishers can be validly compared - subject to there being an adequate sample size for the comparison being made.

Estimates of crab catches by boat-based recreational fishers for the whole of the West Coast Bioregion (i.e. Kalbarri to Augusta) can be compared over time as the sample size for this area from survey to survey is sufficiently large for the catch estimates to be robust. Given that most crab fishing activity in the West Coast Bioregion occurs in the South West, the West Coast Bioregion boat-based crab catch estimate can be considered as a good indicator of crab catches in the South West. However, crab catches by shore-based fishers are not included in these estimates.

Nevertheless, it is still worth examining what information is available from all the various recreational surveys, so that the picture that the information presents can at least be considered (while recognising its limitations). The information presents survey results (with 95% confidence intervals where available) and some limited comment on sampling methodology (Table 3). Where there are varying survey methodologies, comparisons need to be made with caution or to at least take into account how the differing methodologies may affect the estimate.

Table 3 Recreational Survey Results (95% CIs where lower/upper estimates are shown).

Fishery or Bioregion	Survey year	Recreational crab catch estimated from surveys (t)	Methodology	Fisheries Report Reference
Peel-Harvey Estuary	1998/99	251-337	Boats and shore, excludes private jetties, time stratified, daylight hours	FRR 258
	2007/08	107 -193	Boats and shore, including private jetties; time-stratified, daylight hours and evenings	FRR 258
Cockburn Sound	1996/97	16-32	Broad west coast survey of boat-based fishing - Cockburn Sound catch not accurately delineated by survey grid; 8am – 4pm time frame	FRCR 23
	2001/02	14-36	Cockburn Sound focussed study, seasonally varied timeframe extending to evening (8pm in summer)	FRCR 23
	2005/06	3-5	Broad west coast survey of boat-based fishing; 9am to 5pm + 5pm to 10pm Aug 15 to Feb 28 [except 1 Oct to 15 Dec]	FRCR 23
Swan-Canning Estuary	1998/99	7.3	Boat and shore-based fishers; time–stratified; daylight hours only	FRR 126
West Coast Bioregion Fishing from Boat (RFBL) Surveys	2011/12	75 - 97	Phone diary survey; 24 hour coverage, boat-based only	FRR 287
	2013/14	50 - 68	Phone diary survey; 24 hour coverage, boat-based only	FRR 287
	2015/16	36 - 50	Phone diary survey; 24 hour coverage, boat-based only	FRR 287
Geographe Bay	2002	27.0	Boat and shore-based fishers; time–stratified; daylight hours only	FRR 158
	2003	19.8	Boat and shore-based fishers; time–stratified; daylight hours only	FRR 158
Leschenault Estuary	1998	45.7	Boat and shore based; time-stratified, daylight hours only	FRR 120

FRR: Fisheries Research Report;

FRCR: Fisheries Research Contract Report

Despite the occasional nature of some of the estimates (and noting the methodological variation), there is generally a pattern of declining recreational crab catches in all of the estuaries and embayments for which there are catch estimates over time. In particular, the estimated recreational crab catch in the Peel-Harvey Estuary in 2007/08 was, broadly speaking, around half of the estimated catch for 1998/99. This is despite the 2007/08 survey being more comprehensive in its coverage. A reduction in crab abundance is likely to be largely responsible for the reduced catch, although the reduction in recreational bag/boat limits implemented in 2007 may have been a contributory factor.

The Cockburn Sound catch estimates for 1996/97 and 2001/02 are similar, although the 2001/02 survey was more comprehensive in its coverage. The much smaller catch estimate in 2005/06 likely reflects the significant decline in crab abundance which occurred at that time and resulted in Cockburn Sound being closed to crab fishing for 3 years from 2006 until 2009.

The West Coast Bioregion (WCB) RFBL surveys have used a consistent sampling methodology and can be validly compared – although the results only relate to boat-based catches.

The results also cover the whole WCB – but given the predominance of the South West as a crab fishing area, the estimates provide a reasonable guide to crab catches in the South West. The three estimates available (2011/12, 20013/14 and 20015/16) show a declining trend in boat-based recreational crab catches.

Recreational crab catch estimates for Geographe Bay for 2002 and 2003 aren't useful for considering catch trends over time, with the differences being likely to reflect normal, environmentally-driven abundance changes and/or normal year-to-year changes in fisher effort levels. However, the estimates do provide a measure of the size of the catch for this area and some useful information (see later) on catches within part of the winter-spring period. The Swan-Canning Estuary (1998/99) and Leschenault Estuary (1998) estimates do not provide any trend information but do at least provide information on the level of crab catches in those water bodies for those years.

4.0 BACKGROUND BIOLOGY OF BLUE SWIMMER CRABS IN THE SOUTH WEST

Genetic studies at the state and national level have shown that the blue swimmer crab population in the South West is quite distinct from crab populations further north on the WA coast and on the north and east coast of Australia. What this means is that the crab resource in the South West is essentially self-sustaining and that recruitment is not supported by the inflow of blue swimmer crab larvae from other areas (e.g. Shark Bay). This is a very important consideration with regard to how the blue swimmer crab resource in the South West should be defined and managed.

Within the South West area itself, there are some subtle differences in the genetic composition of stocks. The available information indicates that crabs in the Peel-Harvey Estuary and Geographe Bay are genetically similar and likely to be functionally connected reproductively. Crabs from Cockburn Sound, the Swan River and Warnbro Sound form another genetically similar group – although it is likely that this genetic similarity is supported by relatively low levels of larval exchange (as evidenced by the significant stock decline in Cockburn Sound without apparent effects on the other two stocks).

While crab stocks in the South West have, in the past, been treated as separate stocks for management purposes, the reality is that they are likely to be a series of overlapping stocks with varying levels of reproductive and physical connectivity.

Crabs are opportunistic inhabitants of estuaries, moving into these water bodies as the salinities increase in the late spring and summer months and migrating out again into marine coastal waters as the salinity decreases with late autumn/winter rainfall.

Some crabs, however, remain in pockets of saline water trapped in deeper areas (salt water being denser than fresh water), such as the lower reaches of the Swan River or in areas that are well-flushed by coastal marine waters. In the case of the Peel-Harvey Estuary, the re-engineering of the Estuary's hydrological exchange as a result of the cutting-in of the Dawesville Channel has resulted in both the Estuary Channel and the Dawesville Channel, and connections between the two channels, remaining sufficiently saline over the winter and spring months for crabs to continue to live there.

Females spawn their eggs and hold them on their abdomen (i.e. become "berried") in spring/early summer. The eggs develop over about a three-week period (at South West water temperatures) before hatching as larvae. The larvae develop through the various larval stages in coastal waters over about 5-6 weeks before they metamorphose into juvenile crabs and settle in suitable environments. Juveniles which settle in coastal habitats may remain there or migrate into estuaries as conditions within the estuaries become favourable.

There appears to be two spawning periods - early (September to November) and late (December to January). Juveniles (0+ year-class) from the early spawning period are the smaller undersize crabs seen in the estuarine and coastal fisheries over the summer and autumn months. Crabs from the 0+ year class enter the fishery the following year as the 1+ year-class, although because of the spread in spawning times there tends to be variation in their size above and below the 127mm minimum legal size, especially early in the season.

The 1+ year-class also forms the bulk of the breeding stock, although some of the faster growing crabs from the early spawning period may have reached sexual maturity in their first year (as 0+ year class). Newly-matured females are mated for the first time following a moult in late summer/early autumn. Older (legal-sized) females from previous year-classes

also moult, and are mated, during this time. Following the late summer/early autumn moult a high proportion of the 1+ year-class females will grow above the minimum size.

Prior to their late summer/autumn moult, female crabs have a period of low catchability when they cease feeding and become inactive in preparation for the moult. During this period, they are not very catchable by baited traps or drop nets.

Immediately following the moult, while they are still soft-shelled, females are mated. Once the shell hardens, female crabs feed actively as they begin growing additional tissue to fill their expanded shell. Because they are actively feeding they become highly catchable by baited traps and drop nets at this time.

Females store the sperm from their late summer/early autumn mating, using it to fertilise their eggs when they spawn and become 'berried' (carrying eggs on the abdomen) in spring/summer. During the period that females above the minimum legal size are berried they enjoy a brief period of legal protection against being retained by fishers. However, mated, but not yet berried (pre-spawn) females larger than the minimum size in the autumn/winter/spring period are just as important for the egg production of the stock as berried females, but they do not have any protection against being retained by fishers if the fishery season is open.

Blue swimmer crabs in the South West are likely to have a maximum lifespan of around 3 years. Because of their short life-span, the abundance of crabs is heavily dependent on the recruitment success and survival of a small number of year-classes. Given that blue swimmer crabs in South West are near the southern extremity of their natural environmental and temperature range, the presence of favourable environmental conditions is an important factor in the success of a year-class.

The short lifespan of blue swimmer crabs also means that the level of egg production arising from the breeding stock is dependent on a small number of year-classes in the adult breeding stock. This contrasts with longer-lived crustaceans such as rock lobster, which may have upward of 15 year-classes represented in the breeding stock, or other fish species such as dhufish and snapper which (when age structures and year-class strengths are not limited by heavy fishing pressure) may have between 20 and 30 year-classes supporting reproduction. Heavy fishing pressure on crab stocks or poor recruitment in a year can reduce both the strength and number of year-classes in the breeding stock.

Reduction in the number and strength of year-classes, and consequential low levels of egg production by the crab breeding stock, can be aggravated by poor environmental conditions for larval and/or juvenile survival and result in very low levels of recruitment back into the adult population.

Figure 4 illustrates a typical spawning stock - recruitment relationship. Above a certain point (the spawning stock limit reference point), recruitment is mainly influenced by environmental conditions, while at spawning stock levels below that point, recruitment is influenced by both the spawning stock level and the environment. While normal environmental variations will lead to some level of natural variation in the success of recruitment from year-to-year, it is important to ensure that the activities of fisheries in the South West do not drive down the levels of egg production by the breeding stock below the point where limitations in egg production exacerbate the impact of natural environmental factors affecting crab recruitment.

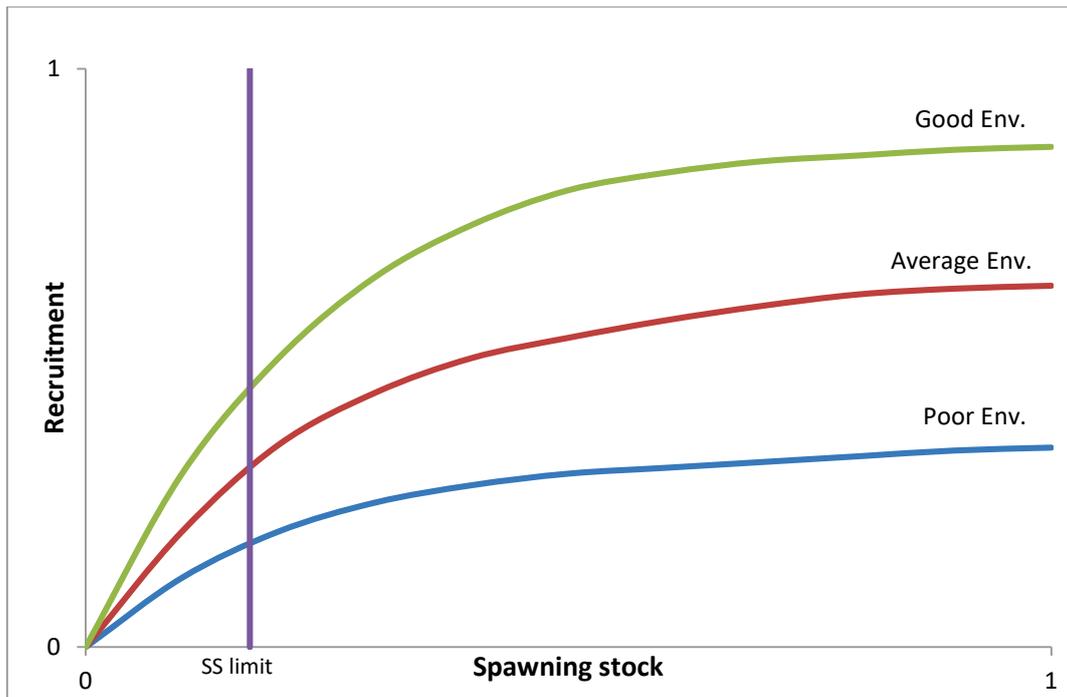


Figure 4. A typical spawning stock - recruitment relationship with three levels of environmental conditions indicated.

At spawning stock levels greater than the limit reference point (SS limit), recruitment is mainly influenced by environmental conditions. At spawning stock levels less than SS limit, recruitment is affected by both the environment and the spawning stock level.

The key message is that the egg production from the breeding stock needs to be maintained at levels which allow the population to withstand the normal environmental variations occurring in this southerly part of the species' range. Current management arrangements do not appear to be achieving this outcome. Fisheries researchers and managers consider that the crab stock would be more resilient if management arrangements were modified so that that the level of egg production to support recruitment was increased through an increased level of protection for female crabs.

5.0 WHAT HAS CHANGED AND WHY DO FEMALE CRABS NEED MORE PROTECTION?

5.1 Commercial Fisheries

With the shift in most commercial fisheries from using nets to using traps in the late 1990s/early 2000s, it became possible for commercial fishers (particularly in coastal and embayment areas) to continue to fish in late autumn and winter (and spring for fisheries open at that time) when, for various reasons, nets were generally not able to be used. Having fishing gear which could be used in open coastal waters also created the scope for the operations of the Mandurah to Bunbury Developmental Crab fishery. This shift in the nature of the fishing gear, and the months and areas in which it could practically be used, had an unanticipated consequence in terms of the exposure of female crabs to fishing mortality.

Because females feed more actively after their late summer/autumn moult (and mating) they are more vulnerable to capture by baited traps than they were to nets used at the same time. The use of traps also allowed the period over which fishing gear could be practically used to extend further into the time of high female catchability. The outcome was that mated/pre-spawned female crabs became exposed to a level of fishing mortality that they had not previously been exposed to.

Table 4 shows the seasonal change in the sex ratio of the catch in the various commercial fishery areas derived from commercial catch data (and research fishing data using commercial trap gear during closed fishery periods). In the coastal and embayment fisheries, the percentage of females in the catch (for months where data is available) is over 50% from at least April through to December, with the female percentage being at least 60% through the winter and spring months. In the Peel-Harvey Estuary, the percentage of females is above 50% in May and then at the mid-low 40% level throughout the winter months. In the Swan River, where the one commercial operator continues to use nets, there is a high percentage of females in the catch in late autumn and winter, although the amount of catch by net in these months is very low.

		Coastal			Embayment	Estuarine	
		Warnbro Sound	Mandurah/Bunbury (Area 1)	Mandurah/Bunbury (Area 2)	Cockburn Sound	Peel-Harvey Estuary	Swan-Canning Estuary (operator uses nets)
Summer	Jan	35	42	ND	26	1	5
	Feb	19	28	54	18	2	9
Autumn	Mar	36	49	62	33	7	10
	Apr	65	60	64	52	45	3
	May	69	80	84	61	57	54
Winter	Jun	76	80	70	60	47	72
	Jul	63	84	ND	66	41	61
	Aug	87	88	ND	69	42	62
Spring	Sep	88	79	ND	72	33	ND
	Oct	ND	77	ND	69	26	5
	Nov	ND	91	ND	64	10	3
Summer	Dec	70	77	ND	53	6	10

-  – Greater than 50% female crabs in the catch
-  – Commercial fishing closure
-  – Recreational fishing closure
-  – No Data

Table 4. Mean monthly percentage of females in the landed catch of the various commercial fisheries over various time periods between 2007 – 2015. Months with >50% female crabs in the catch are highlighted in yellow.

Note: Data for closed seasons is from research fishing using commercial fishing gear.

5.2 Recreational Fisheries

The issue of an increasing take of females does not, however, rest only with the commercial sector. The recreational-only fishery in Geographe Bay is focussed on the take of female crabs, particularly in the winter/spring period. Survey results from 2002 and 2003 for this fishery show that the retained catch over the period July to October in each of these years was around 90% female, with catches over that period in those years being estimated at 8 - 10t.

Recreational fishers have also been active in locating, and fishing, over-wintering crabs in the residual saline areas in the lower reaches of estuaries (notably the Dawesville and Estuary Channel areas of Peel-Harvey Estuary and the deeper waters of the lower reaches of the Swan River). At this time of year female crabs dominate the recreational catch.

5.3 Overall

The shift towards female crabs forming an important component of the catch of both the commercial and recreational sectors has raised concerns that current management arrangements are inadequately protecting the female breeding stock of the South West blue swimmer crab resource and allowing breeding stocks to be driven down to undesirably low levels. While significant stock declines have, at this stage, only been recorded in Cockburn Sound, the generally declining catch level in the South West has raised concerns that breeding stock levels across the resource may be declining towards undesirable levels.

The view of fisheries researchers and managers is that it would be judicious in terms of managing long-term risks to the resource to provide greater protection for the breeding stock, particularly mated pre-spawned females, to increase the level of egg production by blue swimmer crabs above that currently being produced. This will ensure that recruitment is not limited by the level of egg production, although there will still be natural variation in recruitment as a result of environmental variation.

6.0 MANAGEMENT OPTIONS FOR INCREASING PROTECTION OF THE BREEDING STOCK

6.1 Options for increasing protection of the breeding stock

To increase protection of the breeding stock, the management arrangements need to limit the ability of fishers to catch adult crabs – and, in particular females prior to spawning. There are a number of management options⁴ that could be used to achieve this outcome. These are as follows:

- 1) Male-only fishery.
- 2) Increase in the minimum legal size.
- 3) Limiting the ability to catch crabs for all, or part of, the period when female crabs are more vulnerable to capture.
- 4) Closures in areas where females are aggregated and at times when they are more vulnerable to capture (Patchwork seasonal closures).
- 5) Broad-scale area closures to fishing for all, or part of, the period when females are more vulnerable to capture (Broad-scale seasonal closure).

6.2 Evaluating the management options

Option 1:

Male-only Fishery

A possible solution to the take of mated, pre-spawned females would be to prohibit the take of female crabs by commercial and recreational fishers in the South West. This management approach is used for Blue Swimmer Crab fisheries in Queensland.

A male-only fishery rule could operate all-year or in autumn (or part of autumn), winter (and spring in fisheries which are open at that time), when females are predominant in the catch. This option would not, however, prevent fishers from continuing to fish for male crabs at times when females in the population were highly catchable, resulting in ongoing catching, handling and discarding of female crabs.

While crabs are relatively hardy creatures and able to withstand a degree of handling and air exposure, repeated handling increases the risks of negative impacts on survival through effects such as drying (by exposure to air and wind) and temperature changes. Handling will sometimes also result in limb loss, which limits a crab's capacity to move and feed and slows its growth. Crabs are also at greater risk of predation immediately following their return to the water.

⁴ Other options may arise out of the consultation process.

While not wanting to over-emphasize the negative impacts of handling and discard, it is desirable that, where possible, management arrangements should be designed to avoid unnecessary handling and discard of crabs.

The other issue with a male-only rule is that fishers operating at times when females are predominant in the catch may still seek to illegally retain females in order to keep up their catch numbers. Ensuring female crabs are not retained by fishers would require significant compliance resources. At times when females are predominant in the population a male-only fishery would amount to a de-facto closure, but compliance resources would still be required to ensure that females were not being retained by any fishers who chose to go fishing at these times.

A male-only (or seasonally male-only) fishery in the South West would also not be consistent with rules regarding the take of crabs in recreational and commercial fisheries in other parts of the State. While differences in rules in different areas of the State for the same or similar fishing activities are sometimes necessary, they should be avoided where possible – particularly for recreational fishers, who are more likely to move between fishery areas. A male-only fishery rule would also impact on the economic viability of commercial crab fishers at times in the season when their catch contains a mixture of the sexes. For recreational fishers, the quality of the fishing experience would be reduced at times when the catch contains a mixture of sexes, by limiting the crabs that could be retained.

Appendix 1.1 sets out the estimated catch impacts on the various commercial fisheries of a male-only fishery for the periods May to November and July to November. This shows that impacts in the commercial fisheries would be variable, with the greatest impacts in fisheries which are heavily reliant on a take of females.

There is limited data for estimating the impacts on recreational fisheries of a male-only rule. However, the 2002 and 2003 surveys of the recreational crab fishery in Geographe Bay estimated annual catches of 27.0 and 19.8 tonnes respectively, with just under 90% of the catch in both years being female. Recreational crab catches in the winter and spring in the South West are generally low, with the exception of the Geographe Bay fishery where the 2002 and 2003 surveys estimated the catch over the July to October period at 10.2 and 7.5 tonnes respectively, of which just under 90% were female. With either an annual or seasonally applied male-only rule, significant impacts could be expected in the Geographe Bay recreational crab fishery.

Over-focussing the fishery on males also runs the risk of “sperm limitation” if the proportion of male crabs is highly reduced. Male crabs stay with and guard females for about a week prior to their moult and for about a week following the moult (during which time the male mates with the female). This means that there needs to be an adequate ratio of males to females to ensure that females are mated during the fairly narrow window of opportunity for mating. If there are too few males, some females will not be mated, which would limit the production of viable eggs.

Option 2:

Increase in Minimum Legal Size

Currently the minimum legal-size (MLS) for recreational fishers is 127mm CW. The MLS for commercial fishers varies between the different fisheries for various historical reasons and ranges from 127mm to 130mm (Table 2).

Any increase in the MLS could be applied across both sexes (as is the case currently) or applied only to females.

While an increase in the MLS would lead to an increase in breeding stock levels, crabs would be subject to the undesirable and avoidable effects of handling and discard as the size (and, potentially, the sex if the MLS was different for the sexes) of the crab was determined.

It is likely that, initially, there would be a period when fishers (particularly recreational fishers) would be adjusting to the new MLS and significant compliance resources would be required to educate fishers about, and enforce, the new MLS. An increased MLS would also likely exacerbate the current issue of the take of undersize crabs by recreational fishers in the early summer months (see later).

An increased MLS would impact on the economic viability of commercial fishers by limiting the availability of legal-sized crabs, although that impact would vary between the commercial fisheries, given the existing differences in the MLS among the different fisheries and the preference in the commercial market-place for larger crabs. For recreational fishers the quality of the fishing experience would be reduced, because fewer of the crabs caught could be retained.

Appendix 1.2 sets out the estimated catch impacts of various increased MLSs (130mm and 135mm) for both sexes and for females only. Impacts on the annual catch for commercial fishers vary considerably, from almost no impacts on the operator in the Swan River (at the MLSs of both 130 and 135mm, either across both sexes or only applied to females) because the catch of this fishery is primarily large males. The greatest impact in the commercial fisheries for either a 130mm or 135mm MLS applying to both sexes would be in the Peel-Harvey Estuary, with impacts ranging from 15% to 51% respectively. For either a 130mm or 135mm MLS applying to females only, the greatest impact would be in Area 1 of the Mandurah to Bunbury Developmental Fishery, at 8% and 33% respectively.

However, it should be noted that these catch impacts represent short-term losses as some crabs will become available for capture later in the season, or the following season, when they moult and grow above the new MLS.

Data for the various recreational fisheries are more limited and realistic estimates of impacts of any change to the MLS are generally not possible.

Option 3:

Limiting the ability to catch crabs at times when females are more vulnerable to capture

Different methods would be required in the two sectors to implement this option.

i. Commercial: Limiting the number of traps permitted to be used at times when females are more vulnerable to capture.

Within the commercial sector, this approach would require trap usage reductions in all commercial fisheries in at least some autumn months and winter, in addition to September in Warnbro Sound and all spring months (September – November) in the Mandurah-Bunbury Developmental Crab Fishery.

Applying reductions to the number of traps that could be used at particular times of the year decreases the catch of a fishing day and impacts on the economic viability per day of commercial fishers operating at that time. The economic viability per day impacts of any trap

reductions may be able to be dealt with by trap entitlement transfers (in the fisheries where trap use entitlement can be transferred), with fewer fishers using the same number of traps per fisher as before.

There is likely to be a small to moderate increase in the cost of monitoring the compliance of commercial fishers with any seasonal changes in trap numbers. Trap usage compliance checks are a normal, on-going compliance function, but with a seasonal change to trap usage allowances, additional checks would be necessary.

ii Recreational: Reducing bag and boat limits at times when females are more vulnerable to capture.

Reducing bag and, for boat based-fishers, boat limits at the times when females are more catchable would limit the catch of female crabs by the recreational sector. However, this approach would be inconsistent with keeping recreational fishing rules simple and would likely require a high level of compliance oversight to be effective.

The other issue is that bag and boat limits were reduced generally in the West Coast Bioregion in 2007 in response to the significant decline in the crab stock in Cockburn Sound. Any further reduction in crab bag and boat limits, even if only applied over a limited timeframe, would be likely to significantly detract from the experience of recreational crab fishing at those times.

Note: It has not been possible to estimate the impacts on catch of either of these measures.

Option 4:

Closures in areas where females are aggregated and at times when they are more vulnerable to capture (Patchwork seasonal closures)

This option would use closures in areas where, and at times when, females are aggregated and more vulnerable to capture. However, the extent of the area and/or the period of the closure would need consideration. In the estuarine systems, closures would need to operate in areas that remain sufficiently saline over the late autumn, winter and spring months to provide on-going habitat for crabs.

In the Peel-Harvey Estuary this would essentially require a closure to both sectors of at least the Estuary Channel (already closed to commercial fishers) and the Dawesville Channel (already partially closed to commercials and voluntarily not fished in the remaining area). However, it would also need to include the body of saline water connecting these two seawater inflow points. No data are available on the operations of recreational fishers in this area, but information from the commercial fishery shows how commercial fishing gear is set in the more saline waters of the Estuary during the winter months compared to the summer months (Figure 5).

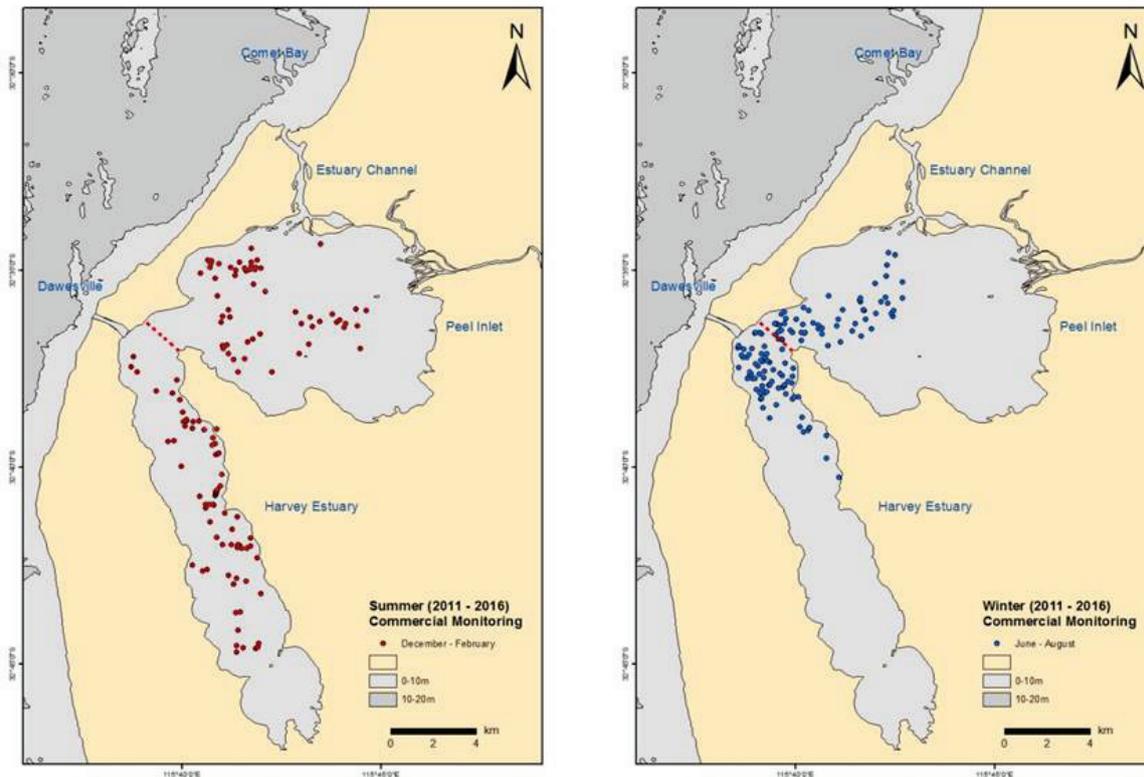


Figure 5. Seasonal distribution of start locations of trap lines in the Peel-Harvey Estuary in summer and winter (2011 to 2016).

For compliance robustness and reasons of equity, a system-wide closure for all or part of the winter-spring period (in addition to the current September – October closure) may be the most appropriate approach for the Peel-Harvey Estuary.

The key area of the Swan-Canning Estuary where crabs aggregate is in the lower reaches of the Swan River and outside the permitted fishing area for the one commercial fisher in that system. A temporal closure in the Swan-Canning Estuary over all or part of the winter and spring months would at least need to include this area of the lower reaches of the Swan River. However, the data on the sex ratios taken by the commercial fisher (Table 4) indicate a high percentage of females in the catches of the winter months – although the catch at that time is low. For compliance robustness and reasons of equity, a system-wide closure over all or part of the winter-spring period may be the most appropriate measure for the Swan-Canning Estuary.

Any temporal area closures would also need to include all coastal waters of the South West (including Cockburn Sound), as these are areas where female crabs dominate the catch from around April to December (Table 4). For the commercial sector this would require closures in late autumn, winter and spring in the two areas of the Mandurah to Bunbury Developmental Crab Fishery as well as in late autumn, winter and September in Warnbro Sound and (when it reopens) in late autumn and the first half of June in the Cockburn Sound Crab Fishery. While the catch impacts on the commercial sector are not able to be estimated directly, they are likely to be significant and of a similar order to those associated with a broad-scale seasonal closure (see below and Appendix 1.3).

A seasonal closure to recreational crab fishing would also be required in coastal areas in all or part of late autumn, winter and spring. This is generally a period of low recreational crab fishing activity in coastal areas, except for Geographe Bay, where there would be significant impacts.

One of the positive aspects of closures is that crabs are not caught at all, so a closure option avoids the undesirable effects of repeated handling and discard of undersize and berried crabs in the closure areas. The costs associated with monitoring the level of compliance with patchwork temporal spatial closures would, however, be moderately significant. The compliance monitoring of closures is relatively straightforward as fishers not complying with the closure are readily detectable. However, in situations where the closure is a patchwork and only applies in particular time periods and in particular areas, enforcing compliance can be more complicated and require more compliance and education resources to implement successfully than a uniform closure. Conversely, the totality of the areas and times that should probably be covered by patchwork seasonal area closures is essentially the same as a broad-scale seasonal closure.

Option 5:

Reducing the period of the fishing season to limit the take of females when they are more vulnerable to capture (Broad-scale seasonal closure)

The option of reducing the length of the fishing season generally to limit the take of females when they are more vulnerable to capture would, in essence, require the commercial and recreational fishing seasons to be closed for the same selected period covering some of the months of autumn and/or winter and/or (where not already closed) spring (i.e. a broad-scale, seasonal closure of the whole of the South West).

A broad-scale closure is a cost-effective compliance measure, as fishers not complying with the closure are readily detectable and the rules are readily understood and recognised as applying uniformly. Closures also avoid any undesirable effects on crabs of capture and handling, as crabs are not caught at all. Given the seasonality of female catchability, seasonal closures could be fine-tuned in their duration to reduce the capture of females to the extent considered necessary.

Broad-scale seasonal closures would clearly have an impact on the quantity of the annual catch taken in both the commercial and recreational fisheries. Within the various commercial fisheries the impacts on the annual catches (and economics) would vary according to the reliance of the fishery on catches in the closure months. Importantly, though, total closures do not erode the economics of commercial fishery operations during the months that they can operate, as it provides the same levels of access to stocks in 'fishing months' as is currently provided.

Appendix 1.3 details the estimated impacts for closures over the periods May to November and July to November in various fisheries. For a July to November closure, the annual catch impacts would be lowest in the Cockburn Sound commercial fishery (0.4% as, when operating, it is closed from 16 June) and highest in the coastal waters fisheries of Warnbro Sound (44%) and Area 1 of the Mandurah to Bunbury fishery (55%). The impacts of a May to November closure are similarly lowest in Cockburn Sound (13%) and highest in the coastal waters fisheries of Warnbro Sound (73%) and Area 1 of the Mandurah to Bunbury Developing Crab Fishery (72%). Table 4 shows that in all key areas of the South West the

crab catch becomes dominated by females in May. A closure commencing in this month would provide the greatest level of protection for pre-spawning female crabs, but it may be that sufficient protection can be achieved with a closure for a somewhat lesser period.

Most of the recreational crab fisheries are less active over winter and spring and impacts would be relatively minor. However, the winter/spring recreational fishery in Geographe Bay and recreational fishers targeting aggregated, catchable crabs in the lower Swan River and the saline areas of the Peel-Harvey Estuary in winter/spring would be affected.

It is not possible to estimate specific impacts in most of the recreational fisheries apart from Geographe Bay, for which there are catch estimates for the July to October period in 2002 and 2003. In the case of the Geographe Bay Fishery a July to November closure (based on the 2002 and 2003 data) would reduce the annual catch by around 34%. However, it should be noted that, with a seasonal closure, recreational fishers would continue to have the same levels of access to stocks in 'open fishing months' as is currently provided.

6.3 Summary of the options

The various breeding stock management options have differing costs and benefits. Table 5 sets out those costs and benefits in terms of:

- Compliance costs
- Impacts on commercial fisher economic viability
- Outcomes for recreational fisher experiences
- Handling and discard
- Improvement in the consistency of the rules

The options which involve more selective retention of the catch (i.e. male-only – all year or seasonal (Option 1) or changing the minimum size limit – generally, or by sex (Option 2) have high compliance costs and impact on the daily economic viability of commercial fishers. While not affecting the continuity of market supply by commercial fishers, the practical effects of these options would be to lower levels of supply from these fisheries when the new rule was operational. These options are also likely to reduce recreational fisher experiences by limiting the numbers of crabs which are available for retention on a fishing trip. They also result in increased levels of handling and discard of crabs.

Options 1 and 2 do not reduce the current complexity of differing seasons and, in the case of a male-only fishery (Option 1), they add further complexity by adding another rule. A male-only rule would add even further complexity if it only applied seasonally. In the case of any changes to the MLS (Option 2), under a new, standard MLS (e.g. 130 or 135mm CW) the current complexity (at least within the South West) would be unchanged – although there would be an increase in complexity on a statewide basis with differing size limits in the various Bioregions. However, the complexity of the rules within the South West would increase if there were different MLSs for male and female crabs (and increase even more if the MLSs were seasonally varied). Complexity of the rules on a statewide basis would also increase.

Option 3 (limiting the ability to catch female crabs at times when they are more vulnerable to capture) would result in reduced handling and discard of crabs, as fewer crabs would be caught. Compliance costs for this option vary between the sectors, but would be high for the recreational sector and moderate for the commercial sector.

This option would increase the complexity of the current rules in both the commercial and recreational sectors, with seasonally varying commercial gear usage levels and recreational bag/boat limits. It would also impact the commercial sector in terms of daily economic viability (except perhaps in fisheries where gear entitlement transfers could be exercised) and limit the supply to the market at times when the new rule was in operation. Recreational fisher experiences would be reduced by the lower bag/boat limits.

With Option 4, there is potential that the seasonal area closures could create a complicated patchwork of time/area closures. Closures are an efficient and effective means of preventing crabs being caught, in that crabs are not subject to any handling/discard and fishers not complying with the closure are readily identified. However, if the closures create a complicated patchwork of areas that are open and closed then compliance effort and education resources need to be expended to ensure that there is compliance with that complicated patchwork of open and closed areas.

There can also be an impact on daily economic viability of commercial fishers, as the areas closed will essentially be the areas of higher catch rates – given that female crabs are the major component of the catch at those times. Recreational fishers will also have reduced fishing experiences, as the high catch rate areas will be closed. The fact that high catch rate areas are closed also potentially creates a compliance problem, as fishers will seek to fish as close as possible to the boundaries of these areas. The reality is, however, that the totality of the times and areas of closure that would be appropriate under a patchwork seasonal closure would probably look very like a broad-scale seasonal closure.

Option 5, a broad-scale (whole of the South West), consistent time-period closure resolves a number of issues. As with other closure or catch-prevention options, there is no handling/discard of crabs. It also removes the current complexity in the rules regarding fishing seasons in the South West, with a single, consistent rule applying to both sectors across the whole area. This will result in a much simpler and more straightforward compliance and education framework.

The broad-scale closure option does not impact on the daily economic viability of commercial fishers at times when the season is open, as they have the same levels of access as they currently do at those times. However, as with all other options, this option impacts on annual commercial fishery economics as well as seasonally terminating supply to the market from fisheries in the South West. Broad-scale seasonal closures will not affect recreational fisher experiences at times when the fishery is open, although they will have an impact when the season is closed.

An important point to note with all options is that the estimates of catch impacts in Appendix 1 have been calculated on the basis that the uncaught catch is totally foregone. This is an oversimplification as crabs that are not caught as a result of the operation of a new rule are available for capture (minus any natural mortality and subject to operation of the new rule) in the future and, generally, at a larger size.

Thus, in Options 3, 4 and 5, all uncaught crabs (minus natural mortality and subject to the new rules) become available the following year. The presence of carried-over (“banked”) crabs in the stock will result in improved catch rates for both sectors, offsetting some of the economic effects on commercial fishers and resulting in improved experiences for recreational fishers.

With an all-year male-only fishery (a sub-option within Option 1) only uncaught males become available the following year. With a seasonal male-only fishery (a sub-option within Option 1), carried-over females would theoretically become available for capture the

following year. However, the seasonality of female catchability means that the bulk of carried-over females would really only become available in autumn/winter/spring of the following year – but would not be able to be retained for some or all of that period depending on when the seasonal male-only rule became operational.

With an increased minimum size (Option 2), and depending on the new minimum size selected, carried-over crabs (minus natural mortality) will become available for capture later in the same year if they moult (grow) to a new size above the new MLS during that year. Otherwise it is likely that they will mostly become available the following year (minus natural mortality). Depending on the size selected for any new MLS, some crabs may not grow above the new minimum size and therefore will never be available for retention.

The other matter to note, however, is that any foregone catch which is “banked” into the stock for future capture may not be available to fishers in the fishery or sector in which the catch has been foregone. Given that crabs move between estuarine and marine environments, and between areas in which recreational fishers and the various commercial fisheries operate, crabs not caught in one year by a fishery or sector may become available for capture in the next year by another fishery or another sector. It is not possible to predict how any changes will play-out in terms of shifts of stock between fisheries and sectors. Nevertheless, overall, the outcome should be a more robust fishery resource with improved catch rates of larger crabs at times when the season is open.

Table 5. Summary of Breeding Stock Management Options.

Option No.	Nature of option	Compliance cost	Impacts on commercial viability	Outcomes for recreational fisher experience	Handling and Discard	Improves consistency of rules
1	Male only	High	Daily – Yes Annual - Yes	Reduced	Increased	Doesn't improve current seasonal closure inconsistencies. Adds an extra rule and may add seasonal inconsistency if only applied seasonally at the time of high female catchability.
2	Increase MLS	High (initially)	Daily - Yes Annual – Yes (Note: impact may vary where commercial fisheries already fishing at a higher size limit).	Reduced	Increased	Doesn't improve current seasonal closure inconsistencies. Only consistent if applied for the whole season and to both sexes. Otherwise adds a seasonal or sex inconsistency.
3	Limiting the ability to catch female crabs at times when they are more vulnerable to capture	Commercial: Moderate Rec: High	Daily -Yes (But gear entitlement transfers may assist) Annual - Yes	Reduced	Reduced	Doesn't improve current seasonal closure inconsistencies. Adds a seasonally-varying gear usage (commercial) or bag/boat limit (recreational) inconsistency.
4	Patchwork seasonal closures	Moderate	Daily – No (but areas that are open will likely be lower catch rate areas) Annual - Yes	Reduced in areas that are open as they will likely be lower catch rate areas.	Reduced	Doesn't improve current seasonal closure inconsistencies. Adds a patchwork of temporally-closed areas.
5	Broad-scale seasonal closures	Low	Daily – No (at times when the season is open) Annual - Yes	Same or Increased (at times when the fishery is open), reduced when the fishery is closed.	Reduced	Removes current seasonal closure inconsistencies.

7.0 POSSIBLE IMPROVEMENTS TO THE OVERALL MANAGEMENT FRAMEWORK FOR THE FISHERY

The possible implementation of new management arrangements to increase protection of the breeding stock in the South West provides an opportunity to consider whether there are other matters that could be dealt with, and integrated into, those changes to deliver improvements to the overall management framework for the resource.

Matters which have been identified as appropriate to consider in this regard are:

1. Reducing management complexity (making the rules more consistent)
2. Reducing the take of undersize crabs by recreational fishers
3. Increasing catch rates, particularly at peak recreational fishing times
4. Reducing the costs of compliance monitoring in the recreational fishery

1. Reducing management complexity (making the rules consistent)

Crab fishing rules covering both commercial and recreational fishing in the South West have developed on a local scale over time, primarily in response to local stock issues and without recognition of the inter-relationships of the different parts of the South West crab resource and the seasonal vulnerability of female crabs. Reducing management complexity by having greater consistency in the rules across the South West, particularly in the recreational sector, is highly desirable.

Of the options examined the only one which removes the current inconsistency of varying closed seasons both within and between the commercial and recreational fisheries is a broad-scale seasonal closure. The other options considered not only don't deal with the current inconsistencies, they add more rules. Within some of those options the new rules would also vary across the seasons, further increasing complexity.

In terms of reduced management complexity, the broad-scale seasonal closure is the only option that achieves this aim.

2. Reducing the take of undersize crabs by recreational fishers

A particular issue with the crab resource in the South West is the high level of take of undersize crabs by recreational fishers. The take of undersize crabs is a particular issue in the estuaries, with compliance data showing that offences related to the take of undersize crabs in the Peel-Harvey Estuary constitutes around 20 percent (20%) of all recreational fishing offences for the state on an annual basis.

The seasonality and relative extent of this issue in the Peel-Harvey Estuary is shown in Figure 6 below. The percentage of detected offences for undersize crabs in the Peel-Harvey, (as a percentage of all Peel-Harvey crab offences) is high across November, December and January and then begins to decline in February and March before falling to very low levels from April through to October.

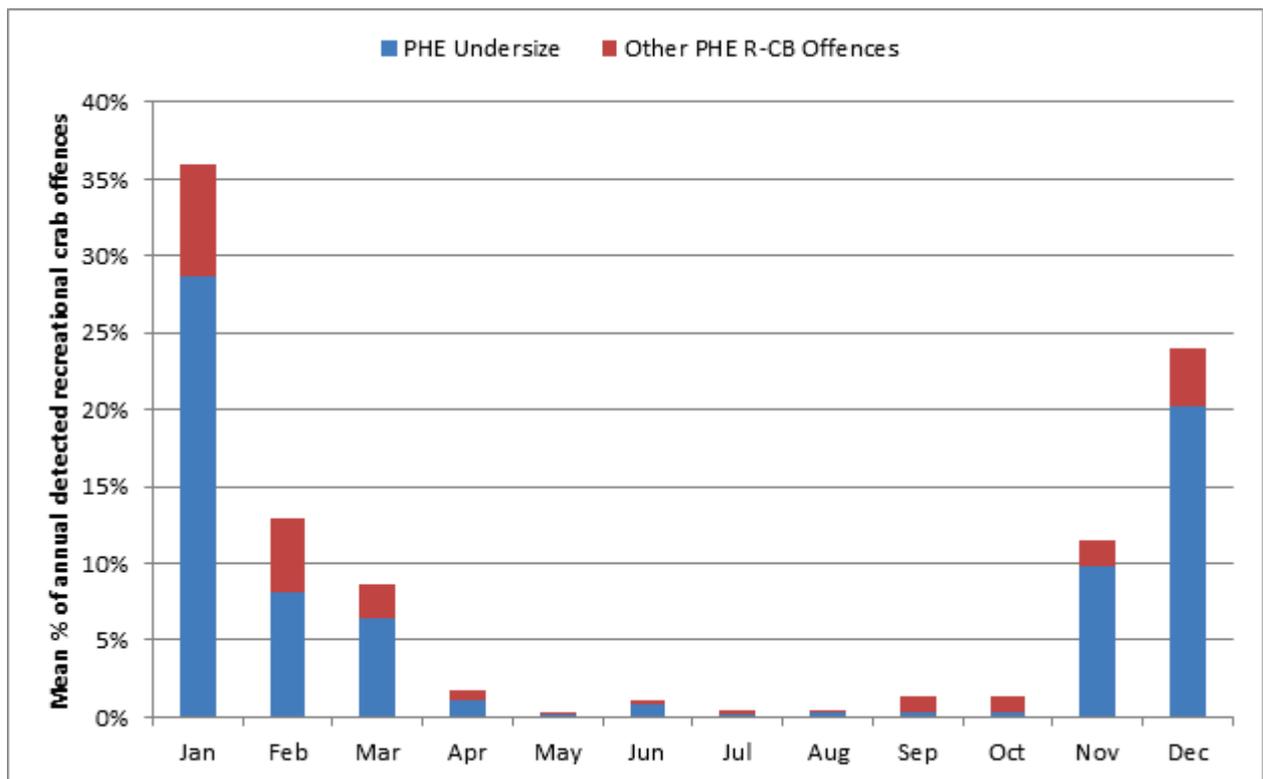


Figure 6. Seasonality and average percentage of annually detected offences by recreational crab fishers in the Peel-Harvey Estuary, (■) Peel Harvey Estuary Undersize and (■) Other Peel Harvey Estuary Recreational-Crabbing Offences. Data is presented by calendar year from 2012 to 2016.

While the detection of offences largely parallels recreational fisher activity patterns, it also reflects the pattern of juvenile crabs entering the populations. As noted in the “Background Biology” section, the size of 1+ year class crabs entering the crab population in late spring/early summer varies around the 127mm minimum size limit. This creates a particular issue in the Peel-Harvey Estuary, which currently opens to fishing in November (the other estuaries do not have closed seasons).

The timing of the September/October closure in the Peel-Harvey Estuary was originally based around the protection of berried female crabs, but has created a situation where the fishery re-opens at a time when undersize crabs form a significant component of the population. Nevertheless, opening the season at this time, potentially has the effect of creating the mindset for recreational fishers that, if the season is open, then it must be reasonable to fish for crabs at that time – and then finding that legal-sized crabs are in low relative abundance in their catch.

Modifying the rules regarding crab fishing in a way that changes the situation of recreational fishers being exposed to a high proportion of undersize crabs in their catch would be an extremely useful outcome of any overhaul of the management arrangements.

One way in which the situation could be changed is to push part of the catchable stock from one year through into the following year. This has the effect of providing fishers operating in

the early months of the season with legal-sized crabs “banked” from the previous year’s fishing season (except in the first year of the rule, when the “bank account” is created).

A slightly later opening (in the Peel-Harvey Estuary at least) would also help, as just undersize crabs would have more time to moult and grow to legal size. In addition, older, larger, crabs in the coastal waters population would have more time to move into the increasingly saline estuary.

A later opening date in the Peel-Harvey Estuary would mean that greater numbers of large crabs had recruited into the estuarine population by the time it opened. Indeed, if a broad-scale closed season is proceeded with, a seasonal closure should include November in any case, on the basis of maintaining protection for females. Consideration should perhaps be given to making any broad-scale seasonal closure extend into the first half of December – which would align with the end of the normal closed season in Cockburn Sound.

It should be noted that all of the breeding stock management options considered will result in crabs which are uncaught in one year becoming available to some extent the following year (minus any natural mortality and subject to the particular rules adopted), resulting in an increase in the relative abundance of larger, older crabs. This increase in relative abundance of larger, older crabs should also result in increased catch rates of legal crabs, at least for fishers operating in the early part of the season.

The extent to which the various options would achieve an increase in the abundance of legal crabs would, however, vary. The male-only option (all-year or seasonal) would limit the availability of “banked” females in the following year. It is also likely that the carry-over of male crabs would be minimal as they would have been targeted in the previous year. This would limit any potential for increased catch rates early in the season, when males are the majority of the catch. The option of increasing minimum size limits will also limit the availability of “banked” crabs in the following year, depending on the size limit selected, as some crabs may not grow through to the new size limit.

The options which limit the catch of crabs generally through catch limitation controls (Option 3) or seasonal-area closures (Options 4 and 5) result in all uncaught crabs (both male and female), minus natural mortality, becoming available the following season - at least until such time as the new rule comes into effect the next season. But the key feature of these options is that any uncaught males, which are the predominant catch in the early part of the season, are available for capture when the season reopens.

3. Reducing the costs of compliance monitoring of recreational fishing.

Currently the recreational crab fishery is open 24 hours a day. To ensure compliance with minimum sizes and bag/boat limits, compliance officers need to be on duty on a 24-hour basis, with sufficient staff resources to properly carry out their functions. This creates significant demands on the staff resources of Fisheries’ offices in the South West.

Compliance staff also advise that large, co-ordinated parties of shore-based crabbers often operate in the hours between 11pm and 3am (particularly in remote areas of the Peel-Harvey Estuary). The size of the groups and the lateness of the hour create a range of issues for compliance officers operating in remote areas around the shoreline of the Peel-Harvey, who need to check the catches of such groups.

The operations of large, co-ordinated groups late at night and in the early hours of the morning requires significant levels of resourcing by the Government to provide adequate and appropriate coverage of these activities.

A possible solution is for a curfew on crab fishing in the Peel-Harvey between, say, 10.30 or 11pm through until, say, 4.30am. There would still need to be a level of checking that the curfew was being complied with, but the compliance framework for dealing with whether or not an activity (crabbing) is being undertaken is a more straightforward matter than whether or not a set of rules related to the take of crabs is being complied with. The use of time closures has operated well in the inshore abalone fishery and recreational netting fisheries for many years and provides a precedent for this approach.

Importantly, having a recreational fishing prohibition from late at night until early morning would not detract from the capacity of most fishers to enjoy fishing for crabs in the evening or around sunrise and would be consistent with it being a family-oriented activity.

8.0 CONCLUSION

All of the management options considered in this Discussion Paper will increase the protection of the breeding stock and will boost egg production through reducing the catch of female crabs. Several of the options would, however, result in increased complexity of the rules and, as a consequence, increased compliance costs. Some of the options also result in increased levels of handling and discard of crabs.

Options 3, 4 and 5, which limit the take of crabs through either gear/bag-boat limit controls (Option 3) or seasonal closures (Options 4 and 5) not only reduce the catch of female crabs but also result in crabs (and, in particular, males) that have been “banked” into the stock becoming available the following season. They also reduce the handling and discard of crabs. Of these three options, however, the broad-scale seasonal closure is the only one that simplifies the rules and, as a consequence, should reduce compliance costs.

A broad-scale seasonal closure will impact on the overall economics of commercial fishers, although the degree of impact will vary between fisheries depending on their level of reliance on catch in the selected period of the closure. The catch of recreational fishers will also be affected by any broad-scale seasonal closure, although the impacts will vary between fishery areas (with the winter/spring fishery in Geographe Bay being particularly affected).

As an offset to these reductions, however, there is likely to be an improvement in catch rates by both commercial and recreational fishers during the times that the fisheries are open, as stock levels will be boosted by the presence of uncaught “banked” crabs.

The matter of the exact period of any closure will need to be considered as part of the consultation process on the proposed overhaul of crab fishing rules in the South West. While various closure periods have been used in the examples, with broad-scale seasonal closures it would be possible to fine-tune the period of the closure in a way which balances the need for increased protection of breeding stock with the impacts in the various commercial and recreational fisheries.

There is no perfect answer as to the extent of the closure that would be required and the period selected will need to balance the benefits of the additional degree of protection provided to the breeding stock against the various fishery impacts. Determining whether any selected closure period has been effective will require on-going monitoring of the stock and, in particular, the relationship between breeding stock levels and recruitment. Catch trends over time should also indicate whether the selected closure period has been effective in ensuring that the breeding stock has been adequately protected. Nevertheless, it would be desirable that any broad-scale seasonal closure include November (and perhaps the first half of December), to eliminate the take of undersize crabs by recreational fishers operating in November and early December under the current Peel-Harvey Estuary season arrangements.

Appendix 1

IMPACT SUMMARIES

The following tables detail the impact some of the management options would have on each of the commercial fisheries of the South West. Where sufficient data exists, the impacts on recreational fishing in the respective fisheries are also included.

In all tables:

- the catch for each commercial fishery is from fisher's monthly returns from 2007-2015;
- the proportion of female crabs and crab size data is derived from commercial monitoring surveys during 2007-2015;
- the 'Estimated Impact on Total Annual Catch' column represents the estimated total percentage annual catch reduction (catch foregone) should the proposed management measure be implemented; and
- the '% Female in Foregone Catch' is the percentage of female crabs in the catch which is foregone.

NOTE: Crabs foregone in one season become available for capture the following season (minus natural mortality) although they may become available to fishers in another fishery or sector.

Appendix 1.1
Male - only option

Male-only Fishery May to November			
Fishery	Sectors	Estimated Impact on Total Annual Catch	% Female in foregone catch
Swan River	Commercial	Catch reduced by 15%	100
	Recreational	Limited data – low effort during winter months	
Cockburn Sound	Commercial	Catch reduced by 8%	100
	Recreational	Limited data – low effort during winter months	
Warnbro Sound	Commercial	Catch reduced by 60%	100
	Recreational	Limited data – low effort during winter months	
Comet Bay	Commercial	Catch reduced by 62%	100
	Recreational	Limited data – low effort during winter months	
Peel-Harvey Estuary	Commercial	Catch reduced by 14%	100
	Recreational	Limited data – low effort during winter months	
Mandurah to Bunbury	Commercial	Limited data	100
	Recreational	Limited data – low effort during winter months	
Leschenault Estuary	Recreational	Limited data – moderate catch impact	
Geographe Bay	Recreational	Limited data – significant catch impact	

Male-only Fishery July to November			
Fishery	Sector	Estimated Impact on Total Annual Catch	% Female in foregone catch
Swan River	Commercial	Catch reduced by 3%	100
	Recreational	Limited data – low effort during winter months	
Cockburn Sound	Commercial	Catch reduced by 0.2%	100
	Recreational	Limited data – low effort during winter months	
Warnbro Sound	Commercial	Catch reduced by 37%	100
	Recreational	Limited data – low effort during winter months	
Comet Bay	Commercial	Catch reduced by 48%	100
	Recreational	Limited data – low effort during winter months	
Peel-Harvey Estuary	Commercial	Catch reduced by 4%	100
	Recreational	Limited data – low effort during winter months	
Mandurah to Bunbury	Commercial	Limited data	
	Recreational	Limited data – low effort during winter months	
Leschenault Estuary	Recreational	Limited data – moderate catch impact	
Geographe Bay	Recreational	Limited data – significant catch impact	

Appendix 1.2

Increased Minimum Legal Size option

Increasing the legal size for <u>all crabs</u> to 130mm			
Fishery	Sectors (and current size limit)	Estimated Impact on Total Annual Catch	% Female in foregone catch
Swan River	Commercial (127mm)	Catch reduced by 0.005%	53
	Recreational (127mm)	Limited data – assumed same as commercial	
Cockburn Sound	Commercial (130mm)	No catch reduction	NA
	Recreational (127mm)	Limited data	
Warnbro Sound	Commercial (127mm)	Catch reduced by 6%	54
	Recreational (127mm)	Limited data – assumed same as commercial	
Comet Bay	Commercial (128mm)	Catch reduced by 11%	71
	Recreational (127mm)	Limited data	
Peel-Harvey Estuary	Commercial (127mm)	Catch reduced by 15%	28
	Recreational (127mm)	Limited data- seasonal variable impact	
Mandurah to Bunbury	Commercial (128mm)	Limited data - Catch reduced by 10%	72
	Recreational (127mm)	Limited data – very low effort level	
Leschenault Estuary	Recreational	Limited data – significant catch impact	
Geographe Bay	Recreational	Limited data – moderate catch impact	

Increasing the legal size for all crabs to 135mm

Fishery	Sector	Estimated Impact on Total Annual Catch	% Female in foregone catch
	(Current size limit)		
Swan River	Commercial (127mm)	Catch reduced by 0.02%	44
	Recreational (127mm)	Limited data – assumed same as commercial	
Cockburn Sound	Commercial (130mm)	Catch reduced by 24%	54
	Recreational (127mm)	Limited data	
Warnbro Sound	Commercial (127mm)	Catch reduced by 27%	57
	Recreational (127mm)	Limited data – assumed same as commercial	
Comet Bay	Commercial (128mm)	Catch reduced by 47%	70
	Recreational (127mm)	Limited data	
Peel-Harvey Estuary	Commercial (127mm)	Catch reduced by 51%	29
	Recreational (127mm)	Limited data – significant catch impact	
Mandurah to Bunbury	Commercial (128mm)	Limited data - Catch reduced by 47%	76
	Recreational (127mm)	Limited data – very low effort level	
Leschenault Estuary	Recreational (127mm)	Limited data – significant catch impact	
Geographe Bay	Recreational (127mm)	Limited data – significant catch impact	

Increasing the legal size for female crabs to 130mm

Fishery	Sector	Estimated Impact on Total Annual Catch	% Female in foregone catch
Swan River	Commercial (127mm)	Catch reduced by 0.003%	100
	Recreational (127mm)	Limited data – assumed same as commercial	
Cockburn Sound	Commercial (130mm)	No catch reduction	NA
	Recreational (127mm)	Limited data	
Warnbro Sound	Commercial (127mm)	Catch reduced by 3.5%	100
	Recreational (127mm)	Limited data – assumed same as commercial	
Comet Bay	Commercial (128mm)	Catch reduced by 8%	100
	Recreational (127mm)	Limited data	
Peel-Harvey Estuary	Commercial (127mm)	Catch reduced by 4%	100
	Recreational (127mm)	Limited data – low to moderate catch impact	
Mandurah to Bunbury	Commercial (128mm)	Limited data - Catch reduced by 7%	100
	Recreational (127mm)	Limited data – very low effort level	
Leschenault Estuary	Recreational (127mm)	Limited data – moderate catch impact	
Geographe Bay	Recreational (127mm)	Limited data – moderate catch impact	

Increasing the legal size for female crabs to 135mm

Fishery	Sector	Estimated Impact on Total Annual Catch	% Female in foregone catch
Swan River	Commercial (127mm)	Catch reduced by 0.01%	100
	Recreational (127mm)	Limited data – assumed same as commercial	
Cockburn Sound	Commercial (130mm)	Catch reduced by 13%	100
	Recreational (127mm)	Limited data	
Warnbro Sound	Commercial (127mm)	Catch reduced by 16%	100
	Recreational (127mm)	Limited data – assumed same as commercial	
Comet Bay	Commercial (128mm)	Catch reduced by 33%	100
	Recreational (127mm)	Limited data	
Peel-Harvey Estuary	Commercial (127mm)	Catch reduced by 15%	100
	Recreational (127mm)		
Mandurah to Bunbury	Commercial (128mm)	Limited data - Catch reduced by 35%	100
	Recreational (127mm)	Limited data – very low effort level	
Leschenault Estuary	Recreational (127mm)	Limited data – moderate catch impact	
Geographe Bay	Recreational (127mm)	Limited data – significant catch impact	

Appendix 1.3

Broad-Scale Seasonal Closure Option

Seasonal closure July to November			
Fishery	Sector	Estimated Impact	% Female in foregone catch
Swan River	Commercial	Catch reduced by 5%	62
	Recreational	Limited data – low effort during winter months	
Cockburn Sound	Commercial	Catch reduced by 0.4%	69
	Recreational	Limited data – low effort during winter months	
Warnbro Sound	Commercial	Catch reduced by 44%	85*
	Recreational	Limited data – low effort during winter months	
Comet Bay	Commercial	Catch reduced by 55%	86
	Recreational	Limited data – low effort during winter months	
Peel-Harvey Estuary	Commercial	Catch reduced by 11%	35**
	Recreational	Limited data – low effort during winter months	
Mandurah to Bunbury	Commercial	Limited data – (Mean catch < 10t)	
	Recreational	Limited data – negligible effort particularly during winter months	
Leschenault Estuary	Recreational	Limited data – low effort during winter months	
Geographe Bay	Recreational	Limited data – High effort during winter months 2002 and 2003 data indicate a July –Oct closure would reduce catch by 34 %.	88 (2002/03)

Seasonal closure May to November			
Fishery	Sectors	Estimated Impact on Total Annual Catch	% Female in foregone catch
Swan River	Commercial	Catch reduced by 23% (Mean catch ~ 10t)	65
	Recreational	Limited data – low effort during winter months	
Cockburn Sound	Commercial	Catch reduced by 13% (Mean catch ~ 48t)	63
	Recreational	Limited data – low effort during winter months	
Warnbro Sound	Commercial	Catch reduced by 73% (Mean catch ~ 20t)	83
	Recreational	Limited data – low effort during winter months	
Comet Bay	Commercial	Catch reduced by 72% (Mean catch ~ 10t)	86
	Recreational	Limited data – low effort during winter months	
Peel-Harvey Estuary	Commercial	Catch reduced by 28% (Mean catch ~ 81t)	64
	Recreational	Limited data – low effort during winter months	
Mandurah to Bunbury	Commercial	Limited data – (Mean catch ~ 10t)	
	Recreational	Limited data – low effort during winter months	
Leschenault Estuary	Recreational	Limited data – low effort during winter months	
Geographe Bay	Recreational	Limited data – High effort during winter months	

* Note that Warnbro Sound is currently closed to fishing during October and November.

** Note that Peel-Harvey Estuary is currently closed to fishing during September and October and that the % of female crabs caught in November is minimal.