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Blue Swimmer Crab (Portunus armatus) Resource in the West Coast Bioregion, Western Australia Part 2: Warnbro Sound, Comet Bay, Mandurah to Bunbury, Leschenault Estuary, Geographe Bay an d Hardy Inlet

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Regional Development

GOVERNMENT OF
WESTERN AUSTRALIA

Fisheries Research Report No. 309

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Johnston, D., Harris, D. and Yeoh, D.

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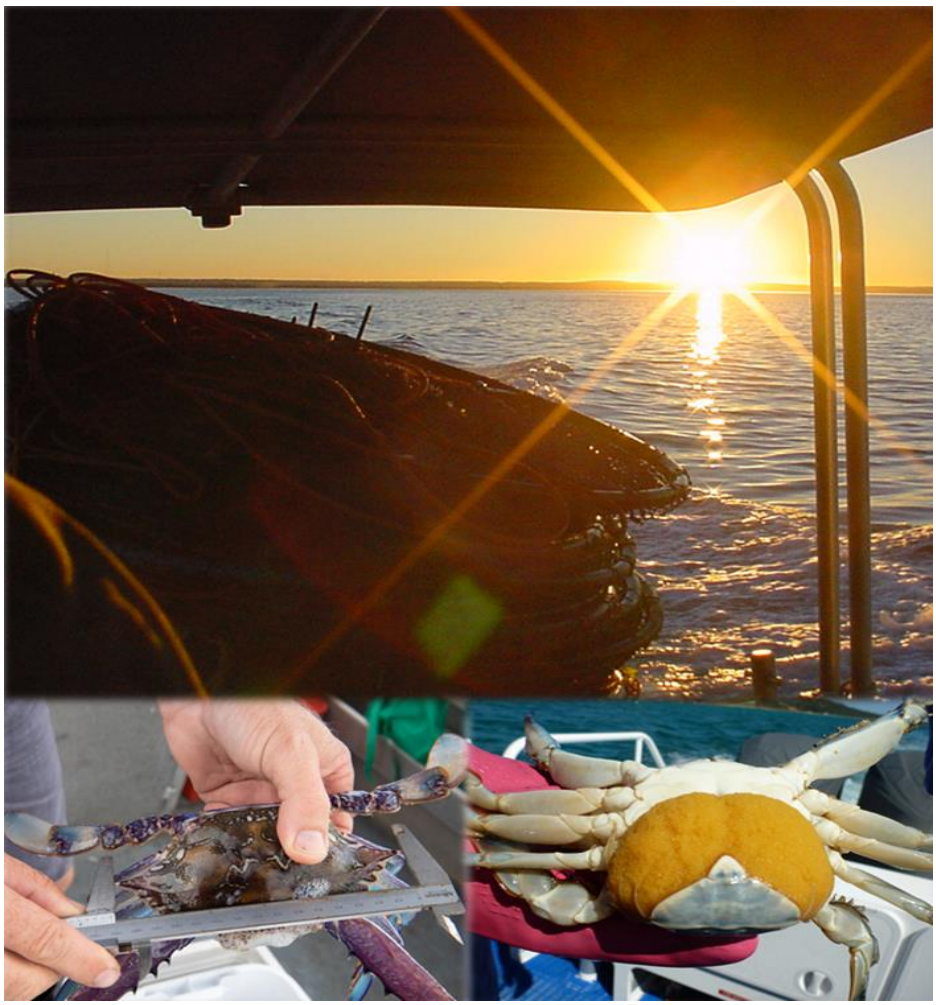

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List of Abbreviations

CAES	Catch and Effort Statistic
CB	Comet Bay (Area 1 of the Mandurah to Bunbury Developing Crab Fishery)
CSCMF	Cockburn Sound Crab Managed Fishery
CW	Carapace Width
DoF	Department of Fisheries (Western Australia)
DPIRD	Department of Primary Industries and Regional Development (Western Australia)
EBFM	Ecosystem-Based Fisheries Management
ESD	Ecologically Sustainable Development
EPBC	Environment Protection and Biodiversity Conservation (Act)
FRMA	Fish Resources Management Act
HI	Hardy Inlet
MB	Mandurah to Bunbury (Area 2 of the Mandurah to Bunbury Developing Crab Fishery)
MBDCF	Mandurah to Bunbury Developing Crab Fishery
MSC	Marine Stewardship Council
PHE	Peel-Harvey Estuary (Area 2 of the West Coast Estuarine Managed Fishery)
RFBL	Recreational Fishing from Boat Licence
RFIF	Recreational Fishing Initiatives Fund
SAFS	Status of Australian Fish Stocks
SCE	Swan-Canning Estuary
SCECF	Swan-Canning Estuary Crab Fishery (Area 1 of the West Coast Estuarine Managed Fishery)
WA	Western Australia
WCEMF	West Coast Estuarine Managed Fishery
WS	Warnbro Sound
WSCMF	Warnbro Sound Crab Managed Fishery

Executive Summary

Blue swimmer crabs (*Portunus armatus*) are found along the entire coastline of Western Australia in a range of estuarine, inshore and continental shelf environments (<50 m).

Crab fisheries in the West Coast Bioregion are centred in the estuaries and coastal embayments from the Swan-Canning Estuary south to Geographe Bay. Major commercial and recreational fisheries in this Bioregion include the Cockburn Sound Crab Managed Fishery, the Swan-Canning Estuary Crab Fishery (Area 1 of the West Coast Estuarine Managed Fishery), and the Peel-Harvey Crab Fishery (Area 2 of the West Coast Estuarine Managed Fishery). Refer to Johnston *et al*. (2020b) for detailed information on these fisheries.

This Research Assessment Report covers the minor commercial and recreational fisheries in the West Coast Bioregion: Warnbro Sound Crab Managed Fishery, Area 1 (Comet Bay) and Area 2 (Mandurah-Bunbury) of the Mandurah to Bunbury Developing Crab Fishery, the Leschenault Estuary and wider Bunbury area, Geographe Bay, and Area 3 of the West Coast Estuarine Managed Fishery (Hardy Inlet). Small amounts of blue swimmer crab are also retained by a single fisher operating under Open Access arrangements around the township of Greenhead, 220 km north of Perth.

Crabbing is a very popular recreational fishing activity, with blue swimmer crabs being one of the most important recreationally fished invertebrate species in the State. The recreational sector primarily targets blue swimmer crabs in the Swan-Canning Estuary, Peel-Harvey Estuary, Leschenault Estuary and Geographe Bay, although recreational fishing occurs throughout most estuarine and nearshore areas of the West Coast Bioregion.

The commercial sector targets blue swimmer crabs using baited hourglass traps, with the exception of the Hardy Inlet where crabs are also retained as by-product in gill nets. The recreational sector fishes for crabs using scoop or drop nets, or by hand while scuba diving or snorkelling.

Management arrangements governing the minor commercial and recreational fisheries in the West Coast Bioregion stipulate a variety of input controls, including a minimum legal size, protection of spawning females, seasonal closures, and effort controls for the commercial fishery.

The total commercial catch of blue swimmer crabs for the West Coast Bioregion in 2019 was 92 t, with 12.2 t landed by the minor fisheries. Total boat-based recreational catch of blue swimmer crabs in the West Coast Bioregion in 2017-18 was estimated to be 54 t (Ryan *et al*., 2019).

A recent review of the south-west blue swimmer crab resource (West Coast Bioregion; Swan-Canning Estuary to Geographe Bay) aimed to improve the level of protection to the breeding stock (mated pre-spawn females), resilience of the resource and the efficiency and consistency of management arrangements across the resource. Management options were outlined in

Fisheries Management Paper 288 - Protecting breeding stock levels of the blue swimmer crab resource in the south west - A review of management arrangements (DPIRD, 2018) and involved stakeholder and public consultation. Revised management measures were implemented in late 2019 and are detailed in this report.

Harvest Strategy, Monitoring and Assessment

Harvest strategies, monitoring and assessment activities for the minor blue swimmer crab fisheries in the West Coast Bioregion assess stock sustainability based on commercial catch rates, juvenile recruitment, breeding stock status, and how the environment may influence these stocks. Harvest strategies and associated control rules developed for the Warnbro Sound Crab managed Fishery, and separately for both Area 1 and Area 2 of the Mandurah to Bunbury Developing Crab Fishery, were subject to Marine Stewardship Certification pre-assessment. As part of the harvest strategies for these fisheries, there are several ongoing programs to monitor commercial catch (and effort), the size and sex composition of harvested crabs, and breeding stock levels. Due to limited data, a draft harvest strategy has yet to be developed for the Hardy Inlet.

Reference levels for each area have been calculated from standardised catch rates observed annually during a period of relative stability when the fishery was considered to have been operating sustainably (Warnbro Sound Crab Managed Fishery: fishing season 2004/05-2011/12; Mandurah to Bunbury Developing Crab Fishery: Area 1 – calendar year 2006-12, Area 2 – calendar year 2004-12). The target range extends between the maximum and minimum values recorded during these reference periods, with the minimum (threshold level) assumed to represent the stock level at which Maximum Sustainable Yield can be achieved. Any stock size above this level is considered to meet the objectives for biological sustainability, and also satisfy stock status requirements under the Marine Stewardship Certification standard for sustainable fishing. A conservative approach has been taken to set the limit reference level at 70% of the threshold value (i.e. $0.7B_{MSY}$) and is considered to represent the level below which recruitment may be impaired.

Industry performance in all crab fisheries is monitored through compulsory catch and effort returns (CAES), as well as daily research logbooks in the Mandurah to Bunbury Developing Crab Fishery as part of Exemption requirements. Assessment of the Warnbro Sound Crab Managed Fishery and Mandurah to Bunbury Developing Crab Fishery also incorporates data from fishery-dependent commercial monitoring surveys which provides information on the stock structure of retained and discarded catch (including bycatch). These data and fishery-independent recruitment and breeding stock trawl surveys are used to calculate long-term annual juvenile and egg production indices.

Fishery-independent breeding stock surveys in the Leschenault Estuary and Geographe Bay commenced in 2013. A recreational fisher logbook program was also implemented to provide temporal and spatial estimates of recreational catch rate and catch composition in these fisheries.

Status of Stocks

Warnbro Sound Crab Managed Fishery

The Warnbro Sound Crab Managed Fishery reported a total annual catch and effort for the 2018/19 season of 6.0 t from 9,870 traplifts, a slight increase from the previous year (3.3 t from 6,460 traplifts). The standardised catch rate for 2018/19 of 0.82 kg/trap lift was an increase from 2017/18 (0.71 kg/traplift). The 2018/19 catch rate is above the harvest strategy threshold of 0.79 kg/traplift, indicating the stock is currently being fished at sustainable levels. On the basis of this evidence, the crab stock in Warnbro Sound is classified as **Sustainable.**

Mandurah to Bunbury Developing Crab Fishery

Total annual catch reported for the Mandurah to Bunbury Developing Crab Fishery in 2019 was 2.4 t from 2,460 traplifts, similar to the catch in 2018 (2.9 t from 5,020 traplifts). All of the 2019 catch and effort occurred in Area 1 (Comet Bay), as Area 2 (Mandurah to Bunbury) has not been fished since 2014.

The mean standardised catch rate for Area 1 in 2019 of 0.9 kg/traplift represented a 34% increase on the previous year. The 2019 catch rate is above the harvest strategy threshold of 0.54 kg/traplift, indicating the stock in Area 1 is currently being fished at sustainable levels. On the basis of this evidence, the crab stock in this region is classified as **Sustainable**.

Leschenault Estuary

The Leschenault Estuary is a recreational-only fishery, as commercial fishing ceased following a Fisheries Adjustment Scheme finalised in 2001. While recreational catch rates obtained through a voluntary recreational angler logbook program have been variable between 2013/14 and 2017/18, the 2017/18 catch rate of 4 retained crabs/10 drop net pulls was the highest recorded over the five-year period.

The 2019 catch rate of sexually mature females from fishery-independent breeding stock surveys was 11.5 crabs/traplift, with an egg production index of 17.8×10^6 eggs/traplift.

On the basis of this evidence, the crab stock in the Leschenault Estuary is classified as **Sustainable.**

Geographe Bay

Geographe Bay is a recreational-only fishery, with commercial fishing ceasing following a Fisheries Adjustment Scheme that was finalised in 2005. Annual recreational catch rates obtained through a voluntary recreational angler logbook program have been relatively consistent between 2013/14 and 2017/18, although the 2017/18 catch rate of 1.8 retained crabs/10 drop net pulls was marginally the lowest within this five-year range.

The catch rate of sexually mature females captured from 2019 breeding stock surveys was 8.9 crabs/traplift, while the egg production index was 15.7×10^6 eggs/traplift.

On the basis of this evidence, the crab stock in the Leschenault Estuary is classified as **Sustainable**.

Hardy Inlet

Little commercial fishing for blue swimmer crabs has historically occurred in Area 3 of the West Coast Estuarine Managed Fishery (annual catch <1.5 t), as the fisher primarily targets fish species using gill nets.

As no commercial landings of blue swimmer crabs have been reported from the Hardy Inlet since 2016, the crab stock in this estuary is currently classified as **Sustainable**.

1. Scope

This document provides a description and assessment of the blue swimmer crab (*Portunus armatus*) resource, and all of the commercial and recreational fishing activities of the minor blue swimmer crab fisheries (Warnbro Sound (WS), Mandurah to Bunbury (MB), Comet Bay (CB), Leschenault Estuary (LE), Geographe Bay (GB) and the Hardy Inlet (HI) impacting on this resource, in the West Coast Bioregion of Western Australia (WCB).

The report contains information relevant to assist the assessment of the resource against the Marine Stewardship Council (MSC) Principles and Criteria for Sustainable Fishing and for other reporting requirements, e.g. Status of Australian Fish Stocks (SAFS).

2. How the Department Operates

Fisheries management in WA has evolved over the last 40-50 years from a focus on managing catch of target species by commercial fishers to a fully integrated Ecosystem-Based Fisheries Management (EBFM) approach, which ensures that fishing impacts on the overall ecosystems are appropriately assessed and managed (Fletcher *et al*., 2010). In line with the principles of Ecologically Sustainable Development (ESD; Fletcher, 2002), the EBFM approach also recognises that the economic and social benefits of fishing to all users must be considered.

Implementation of EBFM involves a risk-based approach to monitoring and assessing the cumulative impacts on WA's aquatic resources from all fishing activities (commercial, recreational, customary), operating at a bioregional or ecosystem level. The level of risk to each resource is used as a key input to the Department of Primary Industries and Regional Development (DPIRD) Risk Register, which is an integral component of the annual planning cycle for assigning activity priorities (research, management, compliance, education etc.) across each bioregion. A summary of the Department's risk-based planning annual cycle that is delivering EBFM in the long-term is provided in Figure 2.1.

To ensure that management is effective in achieving the relevant ecological, economic and social objectives, formal harvest strategies are being developed for each resource. These harvest strategies outline the performance indicators used to measure how well objectives are being met and set out control rules that specify the management actions to be taken in situations when objectives are not being met. The WA harvest strategy policy (DoF, 2015) has been designed to ensure that the harvest strategies cover the broader scope EBFM and thus considers not only fishing impacts of target species but also other retained species, bycatch, endangered, threatened and protected (ETP) species, habitats and other ecological components (Fletcher *et al*., 2016).

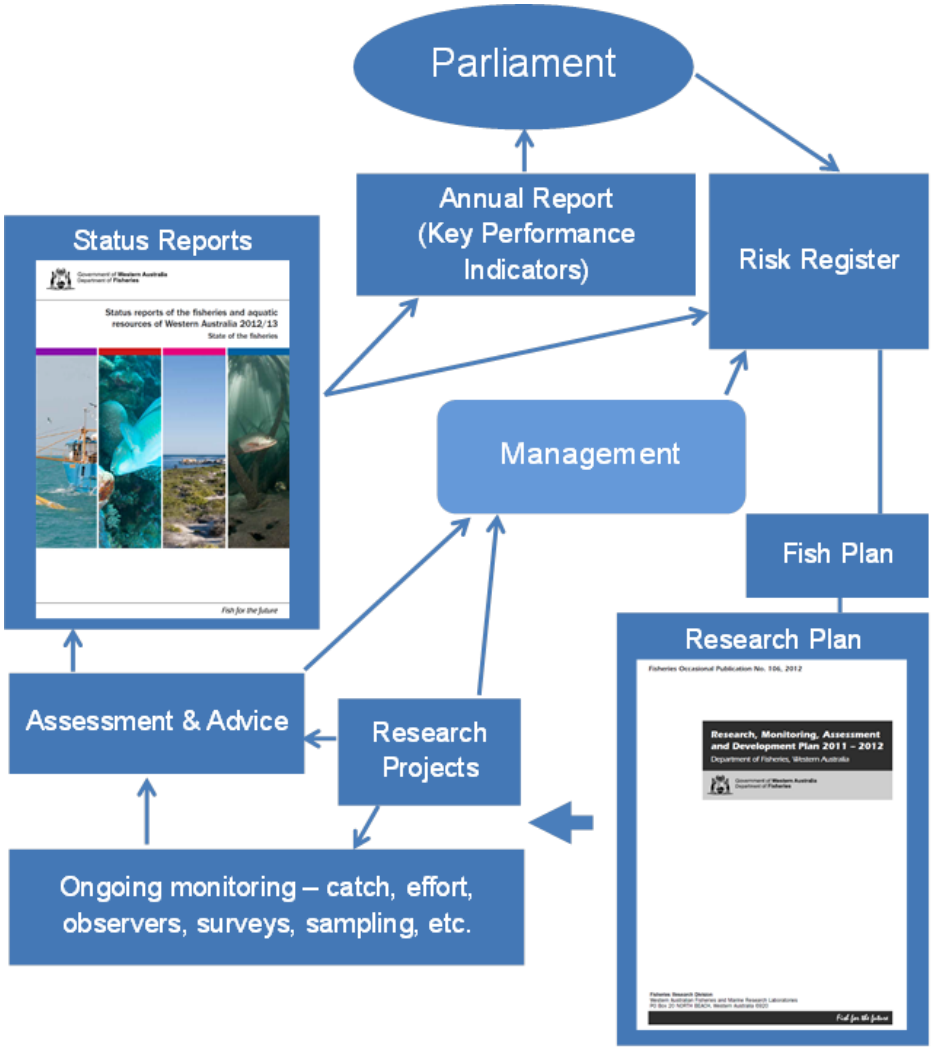


Figure 2.1. An outline of the risk-based planning cycle used for determining Departmental priorities and activities

3. Aquatic Environment

The West Coast Bioregion (WCB) extends from north of Kalbarri to just east of Augusta (Figure 3.1), and encompasses the coastal towns and cities of Geraldton, Perth, Bunbury, Busselton and Dunsborough. Although the waters of the bioregion represent a predominately temperate marine zone (typical range ~15-24 °C), they receive substantial warm tropical water from the southward flowing Leeuwin Current (LC). The region is micro-tidal (*c.* 0.6 m tidal range), and boasts a temperate climate with warm summers and cool winters. Rainfall is protracted and occurs mostly during winter, with average annual rainfall in coastal areas ranging from <400 mm per year in the north (Kalbarri) to ~1000 mm in the south (Augusta).

The LC system, which runs along the entire west coast and can be up to several hundred km wide, varies considerably in strength from year in relation to El Nino or Southern Oscillation Events. The LC's clear, warm, low nutrient waters are key to the growth and distribution of

seagrasses along the coast, and influence the spawning success of many fish and invertebrate species with pelagic egg and larval development stages.

Predominant habitats of the WCB include exposed sandy beaches and limestone reef systems. A long limestone reef system approximately 5 km offshore runs along much of the coast which dissipates wave energy to nearshore coastal areas. The region also contains two significant coastal embayments (Cockburn Sound and Geographe Bay) and several large estuarine systems (the Swan-Canning, Peel-Harvey, Leschenault and Blackwood-Hardy estuaries). Additionally, the bioregion encompasses a unique southern coral reef system at 29° latitude, the Abrolhos Islands.

Aquatic biota in the WCB are predominately temperate, although substantial populations of certain tropical species occur at the Abrolhos Islands and various offshore islands and reef systems southwards. Following a marine heatwave in 2011, tropical species have also been recorded in nearshore and estuarine waters, although generally sporadically and in low numbers.

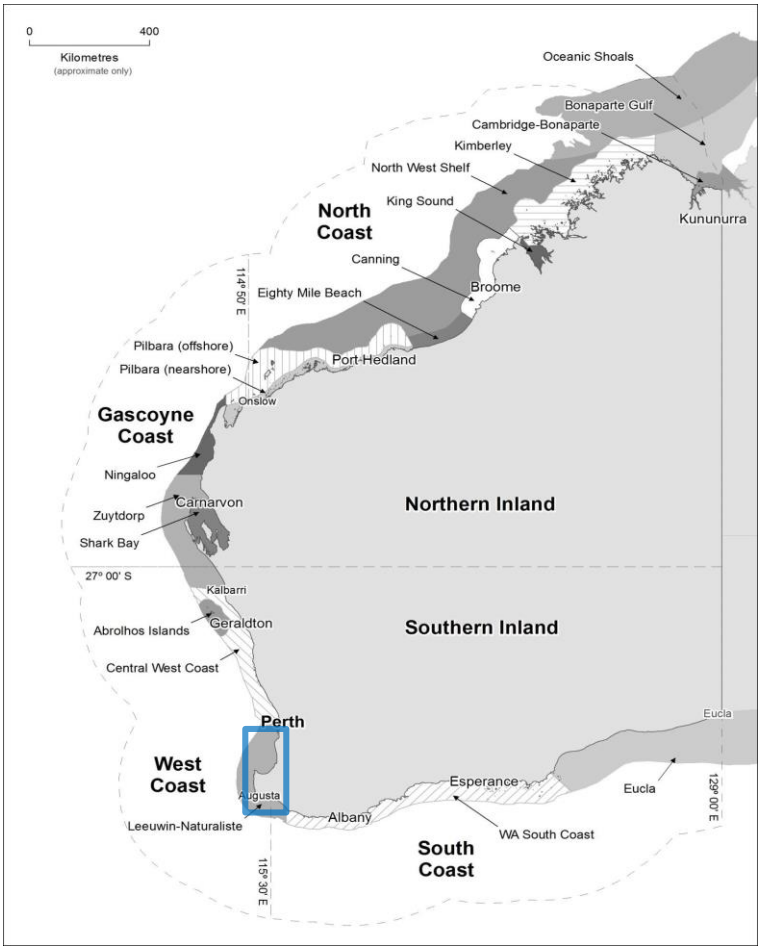


Figure 3.1. Bioregions of Western Australia and the locality of blue swimmer crab stocks in Warnbro Sound, Comet Bay, Mandurah to Bunbury, the Leschenault Estuary, Geographe Bay and the Hardy Inlet, within the West Coast Bioregion. Individual fishery locations are denoted in Figure 4.1

4. Resource Description

Blue swimmer crab (*Portunus armatus*) fisheries in the West Coast Bioregion (WCB) are centred in the estuaries and coastal embayments from Hardy Inlet in the south to the Swan-Canning Estuary and Cockburn Sound in the north. This species resides in sandy bottom nearshore and estuarine habitats up to 50 m in depth.

Commercial fisheries in the WCB include the Cockburn Sound Crab Managed Fishery, the Warnbro Sound Crab Managed Fishery, the Swan-Canning Estuary Crab Fishery (SCECF; Area 1 of the West Coast Estuarine Managed Fishery; WCEMF), Peel-Harvey Crab Fishery (Area 2 of the West Coast Estuarine Managed Fishery), Hardy Inlet (Area 3 of the West Coast Estuarine Managed Fishery) and the Mandurah to Bunbury Developing Crab Fishery (Area 1 - Comet Bay and Area 2 - Mandurah-Bunbury; MBDCF; Figure 4.1). Recreational fishing for crabs occurs throughout the WCB, with effort particularly focused in estuaries and embayments. This Resource Assessment Report focuses on the minor blue swimmer crab fisheries: Warnbro Sound, Comet Bay, Mandurah-Bunbury and Hardy Inlet, and the recreational only fisheries Leschenault Estuary and Geographe Bay.

The blue swimmer crab is a short-lived fast-growing species with a high fecundity and potential for wide dispersal and distribution of recruits. Taking into account these biological traits and the highly specific hourglass traps used by commercial fishers, a Productivity Susceptibility Analysis (PSA) indicates the risk and inherent vulnerability to commercial fishing is low. Nevertheless, collapses of *P. armatus* stocks have occurred in Cockburn Sound and Shark Bay in WA, and in other Australian stocks, where adverse environmental conditions combined with heavy fishing pressure have led to declines in recruitment and breeding stock. Therefore, the vulnerability of the stocks, particularly at the southern extreme of their distribution in south-west WA, is likely to be higher than once thought.

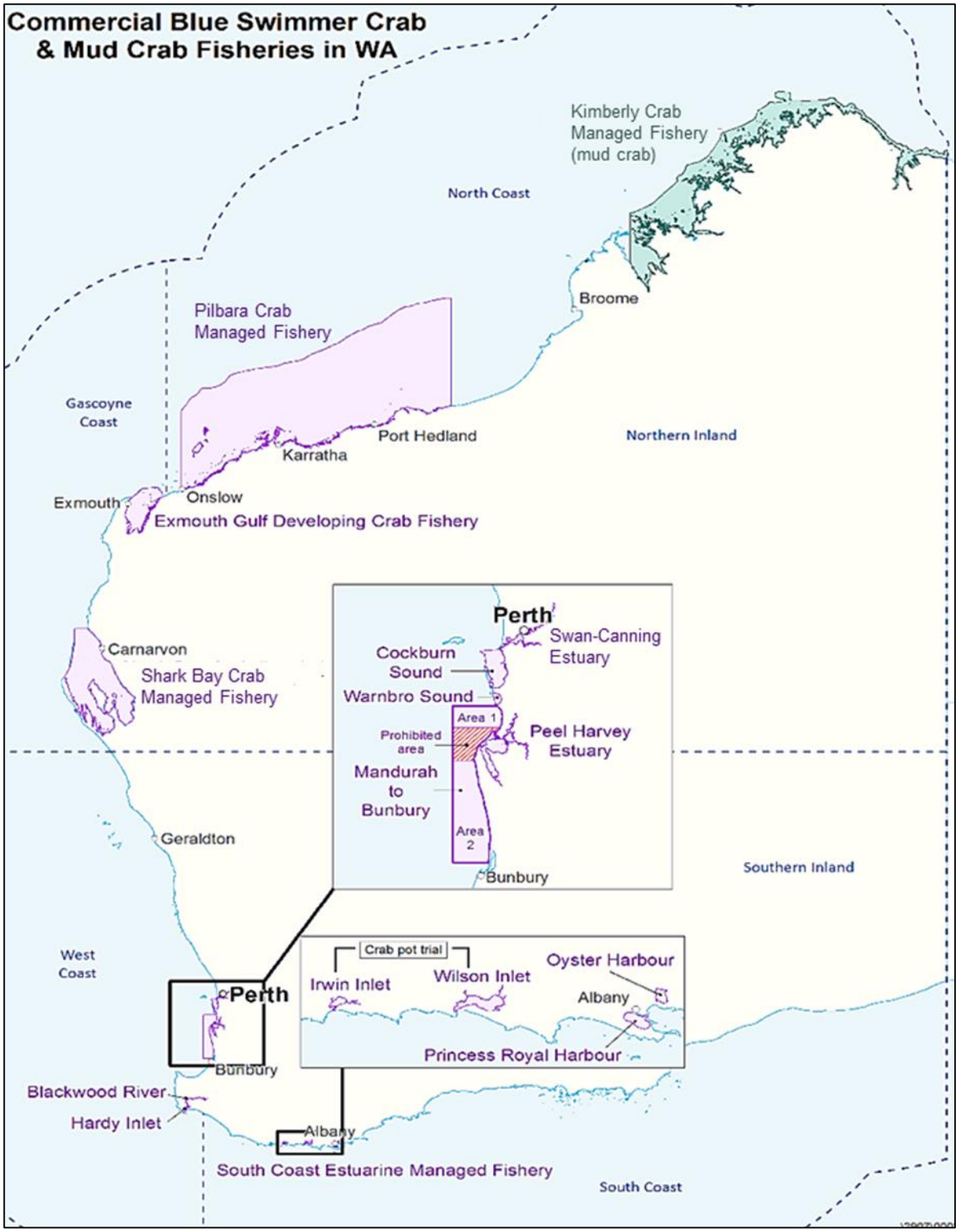


Figure 4.1 Location of the commercially important blue swimmer crab and mud crab fisheries in Western Australia.

5. Species Description

Blue Swimmer Crab (Portunus armatus)

Figure 5.1 The blue swimmer crab, *Portunus armatus*. Illustration © R. Swainston (www.anima.net.au)

For detailed biological information of the blue swimmer crab (Figure 5.1) in south-western Australia, refer to Johnston *et al*., (2020b) Blue Swimmer Crab (*Portunus armatus*) Resource in the West Coast Bioregion, Western Australia. Part 1: Peel-Harvey Estuary, Cockburn Sound and Swan-Canning Estuary.

6. Fishery Information

6.1 Fisheries/Sectors Capturing Resource

The south-west blue swimmer crab resource is targeted by commercial fishers using purpose-designed hourglass traps in Warnbro Sound (WS), Area 1 (Comet Bay: CB) and Area 2 (Mandurah to Bunbury: MB) of the Mandurah to Bunbury Developing Crab Fishery (MBDCF) and Area 3 of the West Coast Estuarine Managed Fishery (WCEMF; Hardy Inlet: HI) (refer to Johnston *et al*., (2020b) for description of other WCB fisheries: Cockburn Sound, Peel-Harvey Estuary; PHE and Swan-Canning Estuary; SCE). They have also been retained as by-product by the South-West Trawl Fishery since the early 1980s, although annual catches were generally low (<3 tonnes) and Zone D (CB) of the fishery closed in 2014. It is one of the most important recreationally fished species (Ryan *et al*., 2019) in Western Australia (WA), with recreational fishers primarily targeting crabs using drop nets, scoop nets, or by hand when snorkelling or diving. Key recreational fisheries in the WCB described in this report include the Leschenault Estuary (LE) and Geographe Bay (GB) (refer to Johnston *et al*., (2020b) for description of other important recreational fisheries Cockburn Sound, Swan Canning Estuary and PHE).

A review of the south-west blue swimmer crab resource was initiated in late 2018 and included the release of *Fisheries Management Paper 288 - Protecting breeding stock levels of the blue swimmer crab resource in the south west – A review of management arrangements* (DPIRD, 2018). The aim of the review was to improve the level of protection to the breeding stock, in particular mated pre-spawn females, and improve resilience of the resource and the efficiency and consistency of management arrangements across the resource. FMP 288 outlined a range of options to achieve this. Having considered public submissions and consulted with peak sector bodies, in August 2019 the Minister for Fisheries announced his decision to implement:

- an annual 3-month (1 September through 31 November) fishing closure (commercial and recreational) in all waters from the SCE to just north of GB,
- a reduced recreational bag limit of 5 crabs in the Swan and Canning Rivers;
- a maximum of 5 female crabs (as part of the 10 bag limit) for recreational fishers in GB; and
- a process to buy back commercial fishing licences in the Cockburn Sound, Warnbro Sound and Mandurah to Bunbury Crab Fisheries prior to their permanent commercial closure.

The Department is now implementing the Minister's decisions and also working with Recfishwest, WAFIC and the Southern Seafood Producer's Association to consider other potential changes to the management of the south-west blue swimmer crab resource.

The section(s) below provide more detailed information about the minor fisheries /sectors that target the south-west crab resource.

6.2 Commercial Fishery

6.2.1 Warnbro Sound Crab Managed Fishery

6.2.1.1 History of Development

The Warnbro Sound Crab Managed Fishery (WSCMF) covers the waters of Warnbro Sound (WS) inshore from a line drawn from Becher Point in the south to Mersey Point in the north.

A single commercial licence has been endorsed to target blue swimmer crabs in WS since the establishment of the WSCMF in 1985. The fisher used gillnets during the first ten years of the fishery, with relatively low annual catches reported (< 5 t). Trialling of purpose-designed, baited hourglass traps began in 1994, converting to a trap-only fishery from 1996. The licensee is endorsed to use a maximum of 100 traps.

A two-month closure over the peak spawning period (October and November) was introduced in September 1995, so since this time the annual WSCMF fishing season has spanned 1st December to 30th September inclusive.

Annual catch during the gill net period of the WSCMF ranged from 2 to 4 t from between 30 and 110 days fished per year (~2-64 km net length) (Figure 6.1; Figure 6.2). The annual catch fluctuated between 3 and 17 t between 1996/97 and 2008/09 from 80 to 250 days fished per

year (900-20,900 traplifts). Catch and effort increased substantially over the next three years, to peak at 35 t in 2011/12 from 26,700 traplifts (267 days fished; Figure 6.2). Although these high catch levels were maintained in the 2012/13 season (29 t), subsequent annual catches declined sharply to less than 2 t in 2014/15 when a voluntary closure was implemented due to the low stock abundance. Fishing recommenced in 2015/16, with a total annual catch of 13 t. However, subsequent catches have remained low (~5 t; Figure 6.1; Figure 6.2).

A management review focused on increasing protection of the south-west blue swimmer crab breeding stock at a resource level (DPIRD, 2018). The review resulted in the closure of the WSCMF undergoing a Voluntary Fishery Adjustment Scheme (VFAS), which is due to be finalised in 2021.

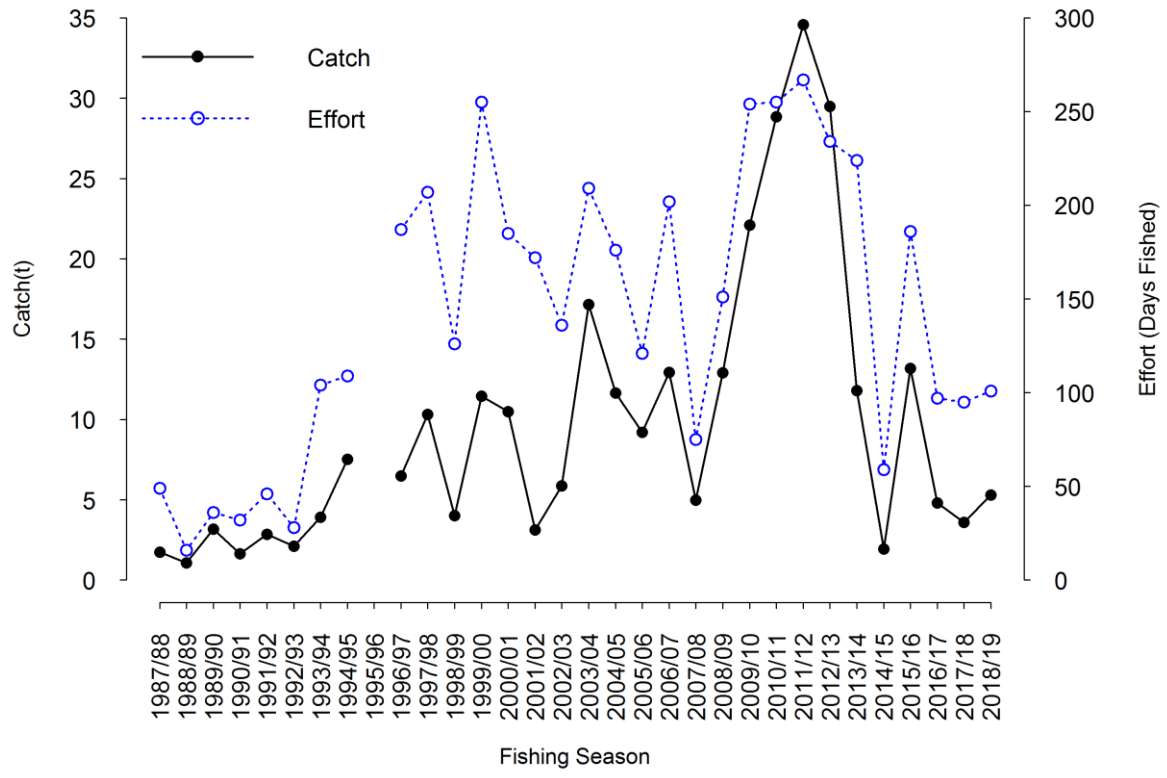


Figure 6.1 Total annual commercial catch (tonnes) and fishing effort (days fished) by fishing season (1st December–30th September) for all fishing methods in the Warnbro Sound Crab Managed Fishery between 1987/88 and 2018/19. No fishing occurred in 1995/96.

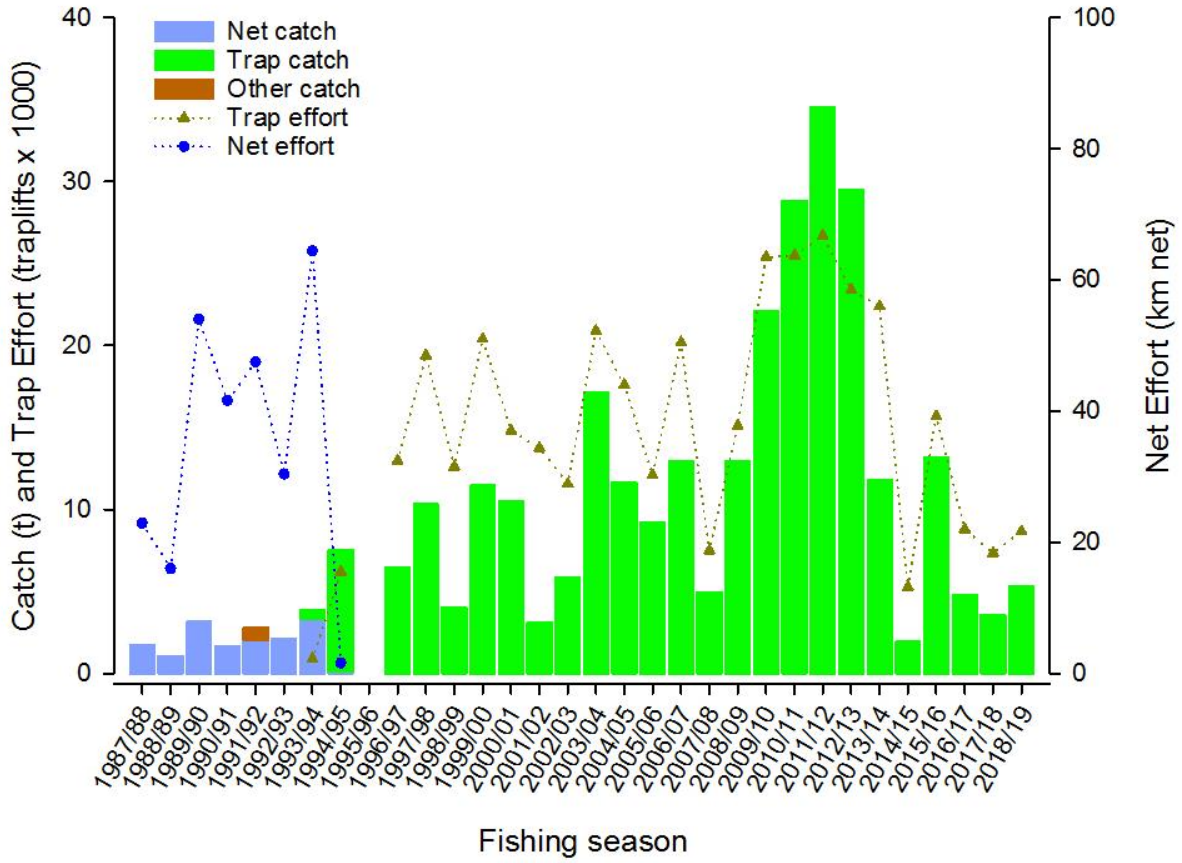


Figure 6.2 Annual commercial catch (t) and effort (Net: km net, Trap: traplifts x 1000) by fishing method for each fishing season (1st December–30th September; spawning closure covers October and November) in the Warnbro Sound Crab Managed Fishery between 1987/88 and 2018/19. Note, fishing occurred year round to 1995, so catch between 1987/88-1994/95 represents a 12-month period from 1st December-30th November in these years. No fishing occurred in 1995/96. Other refers to crab landings by beach seine.

6.2.1.2 Current Fishing Activities

A summary of key attributes of the current WSCMF and the fishing fleet is provided in Table 6.1.

The WSCMF encompasses the waters of Warnbro Sound, and nearshore waters to the west stretching from the northern end of Cape Peron (John Point) south to Becher Point (Figure 6.3). However, the current endorsement allows fishing in only that portion of the Fishery lying west of a line starting at the western extremity of Becher Point in Warnbro Sound and extending in a northerly direction to the western extremity of Mersey Point (Figure 6.3). Refer to the Warnbro Sound (Crab) Limited Entry Fishery Notice 1995 for details of specific fishery boundaries and management areas.

A seasonal closure was introduced in the WSCMF in 1995 covering the peak spawning period from 1 October to 30 November. A management review focused on increasing protection of the south-west blue swimmer crab breeding stock at a resource level (DPIRD, 2018) resulted in the extension of the spawning closure to include the month of September from 2019. The majority of product is sold locally from an entitlement of 100 traps.

Table 6.1 Summary of key attributes of the commercial Warnbro Sound Crab Managed Fishery

Attribute	
Fishing methods	Hourglass crab traps
Fishing capacity	100 traps
Number of licences	1 (active)
Number of vessels	1
Size of vessels	11.6 m
Number of people employed	2
Value of fishery	< $0.1 million (2018/19 season GVP at $6.16/kg) Level 1

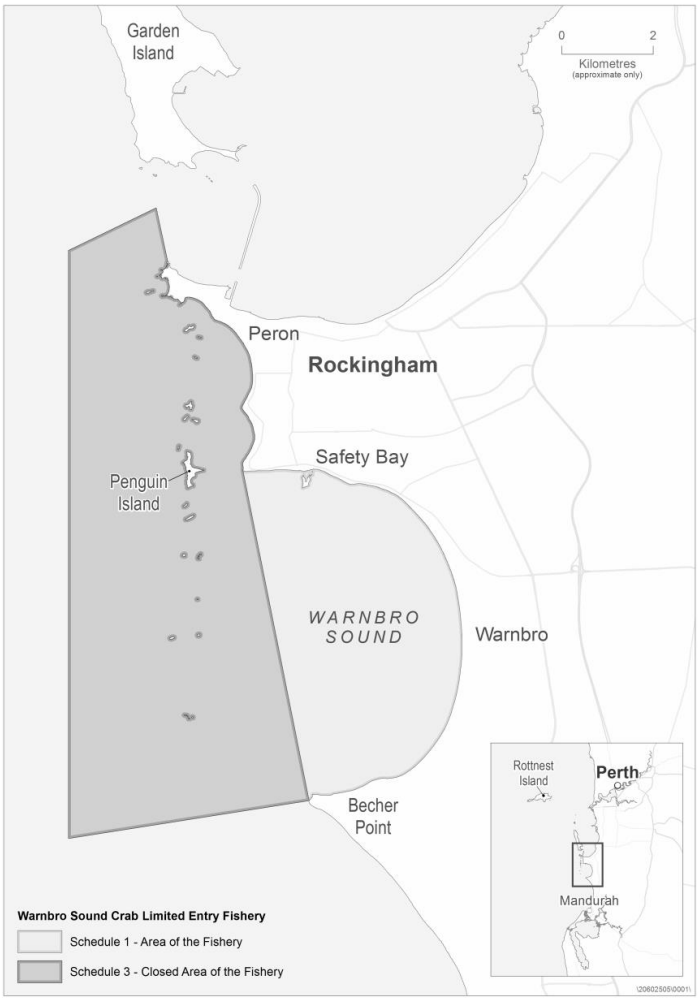


Figure 6.3 Boundaries of the Warnbro Sound Crab Managed Fishery and its closed areas.

6.2.1.3 Fishing Methods and Gear

The WSCMF targets blue swimmer crabs using purpose-designed, baited hourglass traps. Traps must have two rings each of diameter ≤1.16 m with a height between the rings when set ≤0.45 m (Figure 6.4), and be attached by negatively buoyant rope to a float that has a diameter of not less than 190 mm and branded with the fisher's LFB number. The base ring is reinforced to provide weight to counter ocean swells that impact this fishery. Traps typically have one, two or three pairs of opposing side entry funnels. Escape gaps and mesh size are not legislated in this fishery. However, the current fisher has voluntarily introduced escape gaps based on those used in the Peel-Harvey crab fishery, and covers his traps with 89 mm (3.5 inch) mesh to minimise the retention of undersize crabs (Figure 6.4).

The traps are baited with various finfish species (frames, heads and whole fish), the majority of which is sourced as by-product from other commercial fisheries operating within WA. The fisher can use a maximum of 100 crab traps, usually set in lines of 10 traps, and can only be pulled once in any 24-hour period.

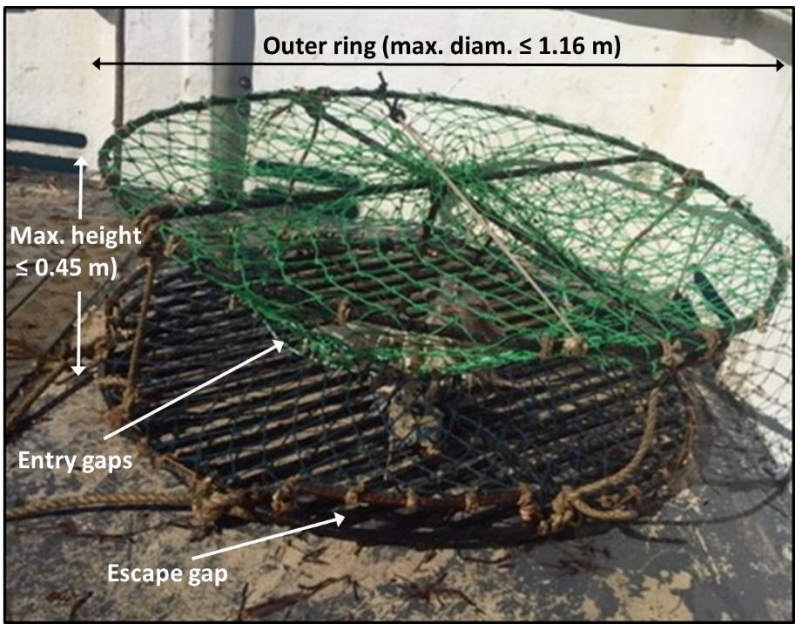


Figure 6.4 A commercial hourglass crab trap used in the Warnbro Sound Crab Managed Fishery

6.2.1.4 Susceptibility

For the purposes of Productivity and Susceptibility Analysis (Section 9.3.6), the blue swimmer crab assemblages in WS will be deemed a single stock.

The WSCMF covers an area of approx. 44 km^2, with a high proportion providing suitable habitat for the blue swimmer crab. Due to the spatial distribution of this stock throughout the embayment and the expansive area fished by the commercial sector, areal overlap is likely to be high (>30%).

As the purpose-designed baited hourglass crab traps used in the WSCMF are set on the sea bed, the encounterability with the blue swimmer crab stock is high as they are primarily a

benthic dwelling species. However, vertical overlap is considered moderate as the mesh size and escape gaps used in this fishery enable the majority of undersize crabs to escape capture.

Blue swimmer crabs can survive out of water for up to several hours provided their gills remain moist. As regulations stipulate the commercial fisher in the WSCMF must return berried and undersize crabs to the water within 5 minutes of being landed, post-capture mortality of non-retained catch with and without exposure to ice-slurries is low (Bellchambers *et al*., 2005; Leland, 2014; Uhlmann *et al*., 2009).

6.2.2 Mandurah to Bunbury Developing Crab Fishery

6.2.2.1 History of Development

The MBDCF operates in nearshore marine waters adjacent to the PHE (Area 1 - Comet Bay) and between the PHE and the Leschenault Estuary (Area 2 - Mandurah-Bunbury).

Blue swimmer crabs have been retained as by-product by trawlers operating in the area of the MBDCF since 1983, with the use of purpose-designed traps to target crabs first trialled in CB in 1988 as a permissive condition on a Fishing Boat Licence of a single commercial operator (Figure 6.5). Since participating in the Oceanic Crab Pot Trial in CB in 1994, the current exemption holder has been the sole trap fisher in this embayment. The MBDCF was established in 2002 through an initiative to investigate the commercial viability of fishing for blue swimmer crab in previously unexploited areas of the WA coast consistent with the zone approach to developing the WA inshore crab fishery that was introduced in 1997 (Campbell, 1997). One 80-trap exemption was issued to fish in Area 1 (CB), while four 60-trap exemptions were issued for Area 2 (MB). However, only the CB fisher and two fishers (from one commercial operation) in MB have had a significant history in this fishery. The two active MB trap exemptions were subsequently combined to form a single 120-trap exemption in 2007.

Annual commercial blue swimmer catch from the MB region increased steadily from 2 t in 1983 to a peak of 27 t in 2004 (Figure 6.5). Most of the catch between 1983 and 2002 was landed by trawlers operating in Zone D of the South West Managed Trawl Fishery, after which trap catch became more important. Trawling ceased in 2014 when Zone D was discontinued. Following the annual trap catch of 29.6 t from 23,480 traplifts in 2010 (Area 1: 9.7 t from 12,800 traplifts; Area 2: 20 t from 10,680 traplifts), annual catch declined steadily to just 2.4 t from 2,460 traplifts in 2019 (Figure 6.5; Figure 6.6). This decline was due to minimal fishing effort in MB (Area 2; Figure 6.7) over this period, and a reduction in effort in CB (Area 1) as the fisher concentrated on an endorsement acquired in 2015 to target blue swimmer crabs in WS.

A management review focused on increasing protection of the south-west blue swimmer crab breeding stock at a resource level (DPIRD, 2018). The review resulted in the MBDCF undergoing a VFAS, which is due to be finalised in 2021.

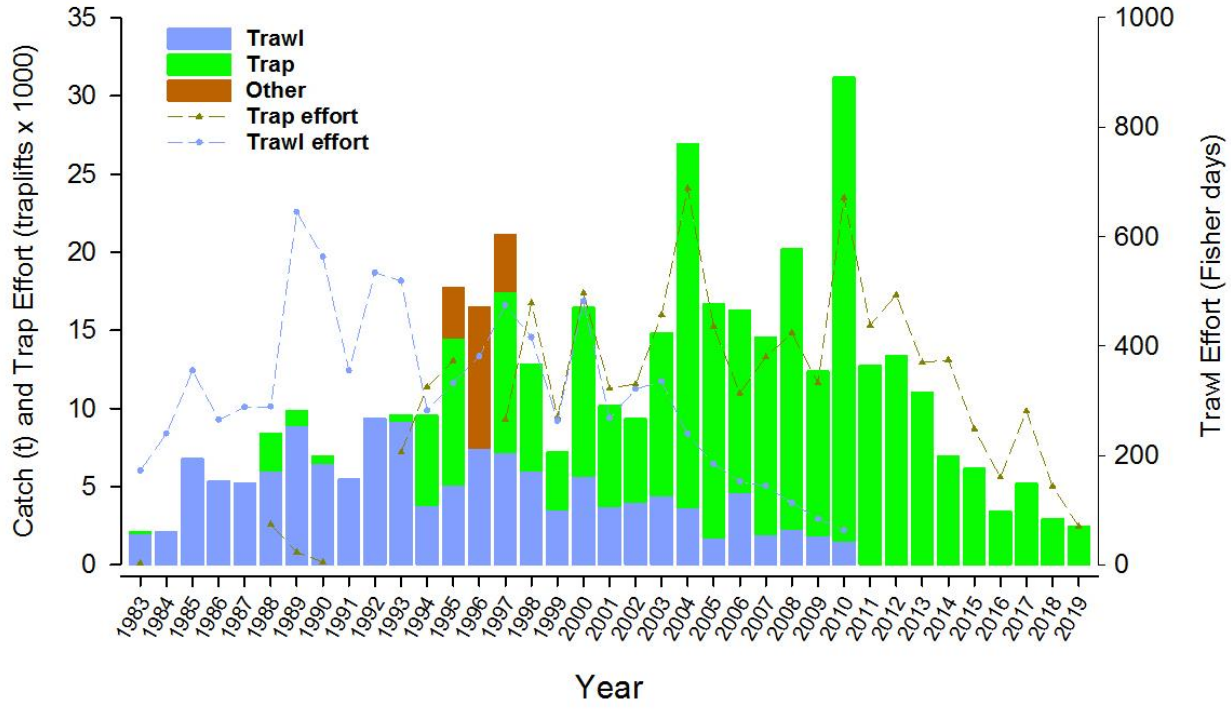


Figure 6.5 Annual commercial blue swimmer crab catch (t) and effort (Trawl: fisher days, Trap: traplift x 1000) by method for the Mandurah to Bunbury region between 183 and 2019. Other represents fishing by gill net, beach seine and purse seine.

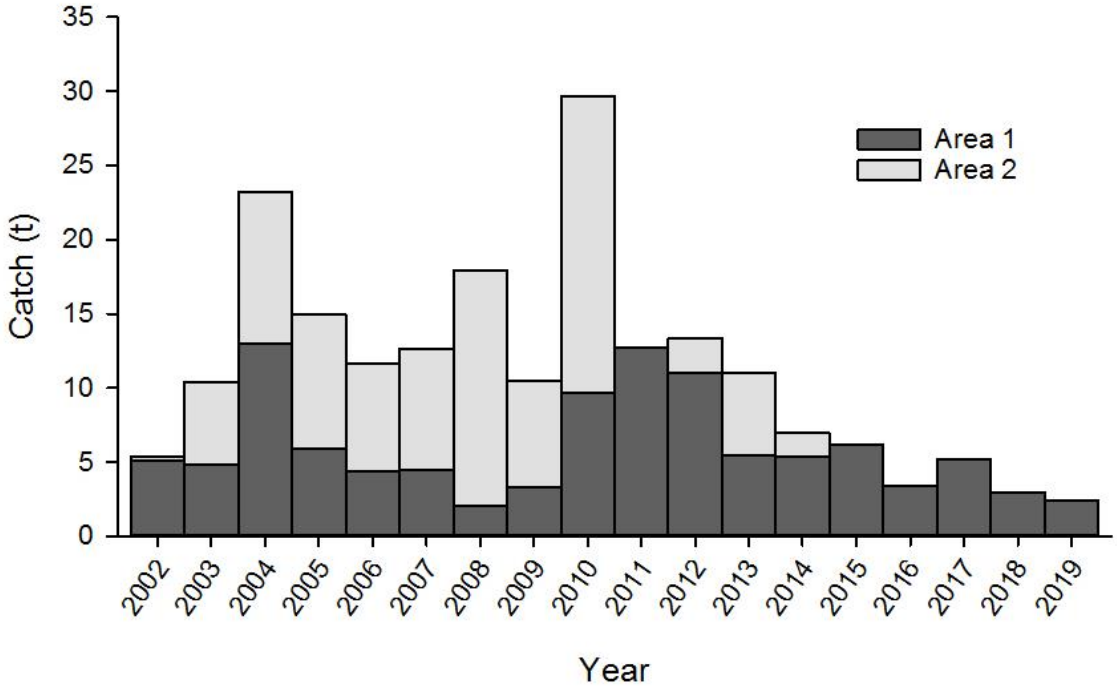


Figure 6.6 Annual commercial trap catch (tonnes) of blue swimmer crabs by calendar year for Area 1 (Comet Bay) and Area 2 (Mandurah to Bunbury) since the inception of the Mandurah to Bunbury Developing Crab Fishery (2002-19).

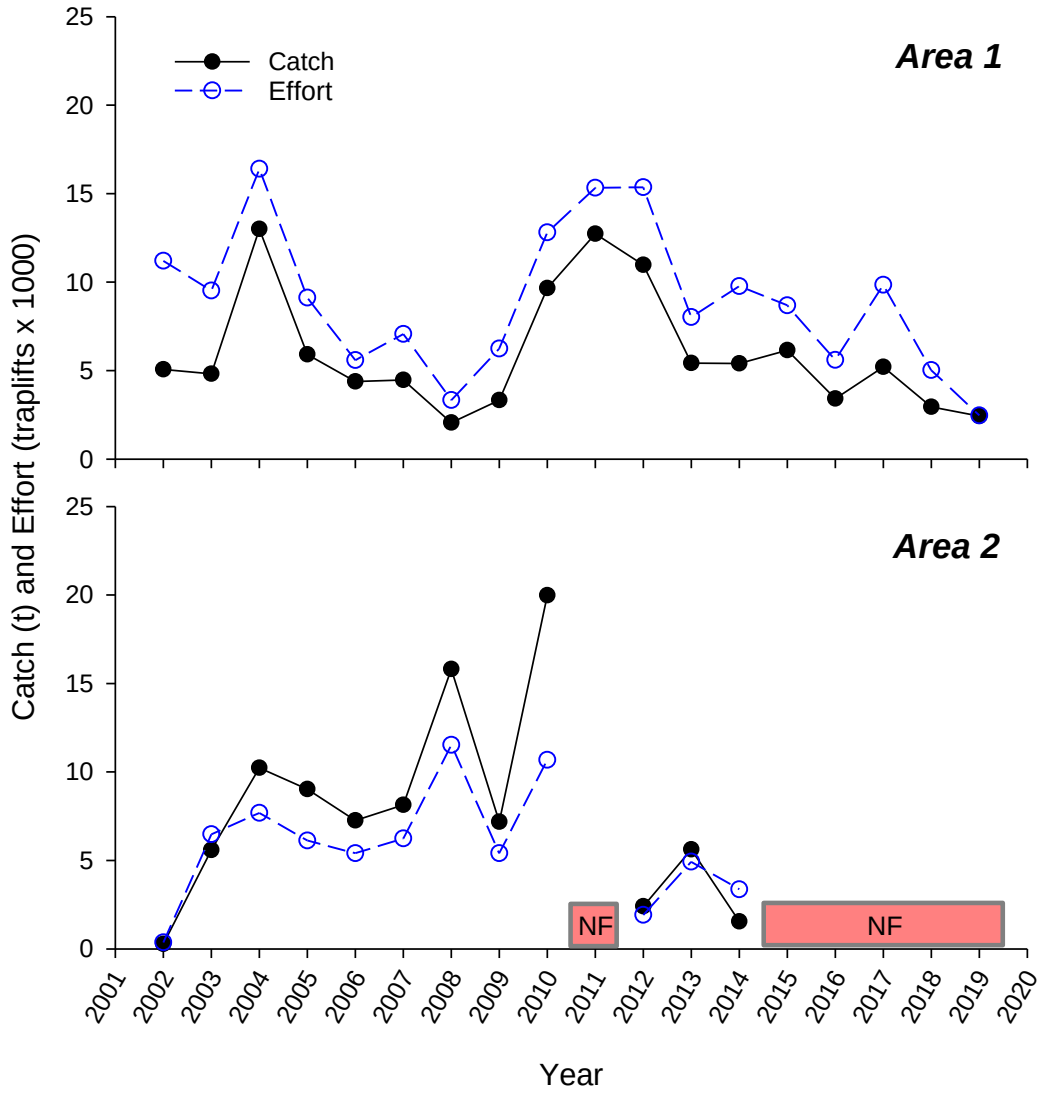


Figure 6.7 Annual commercial blue swimmer crab trap catch (tonnes) and fishing effort (traplifts x 1000) by calendar year for Area 1 (Comet Bay) and Area 2 (Mandurah to Bunbury) since the inception of the Mandurah to Bunbury Developing Crab Fishery (2002-19). NF: No fishing occurred in Area 2 in 2011, or after 2014.

6.2.2.2 Current Fishing Activities

A summary of key attributes of the MBDCF and its fishing fleet is provided for CB in Table 6.1 and MB in Table 6.2.

The MBDCF encompasses the waters south of the Shoalwater Islands Marine Park (32°22′40″ S) to Point McKenna near Bunbury (33°18′ S), and offshore to 115°30′ E. The fishery is further divided into two zones: a single northern zone (Area 1) authorising fishing for crab in a specified area of Comet Bay between latitudes 32°22′40″ S and 32°30' S; and a single southern zone (Area 2) covering the waters between Cape Bouvard and the southern boundary of the fishery. The area separating the two zones (32°30' S southwards to Cape Bouvard) is closed to

commercial crab fishing (Figure 6.8).

There is no seasonal closure in the MBDCF.

Table 6.2 Summary of key attributes in Area 1 (Comet Bay) of the Mandurah to Bunbury Developing Crab Fishery.

Attribute	
Fishing methods	Hourglass crab traps
Fishing capacity	80 traps
Number of licences	1 (active)
Number of vessels	1
Size of vessel	11.6 m
Number of people employed	2
Value of fishery	<$0.1million (2019 year GVP at $6.16/kg); Level 1

Table 6.3 Summary of key attributes in Area 2 (Mandurah-Bunbury) of the Mandurah to Bunbury Developing Crab Fishery. Note fishing has not occurred since 2014.

Attribute	
Fishing methods	Hourglass crab traps
Fishing capacity	120 traps
Number of licences	1 (currently inactive)
Number of vessels	1
Size of vessel	12.5 m
Number of people employed	3 (0 for 2019)
Value of fishery	$0 (for 2019)

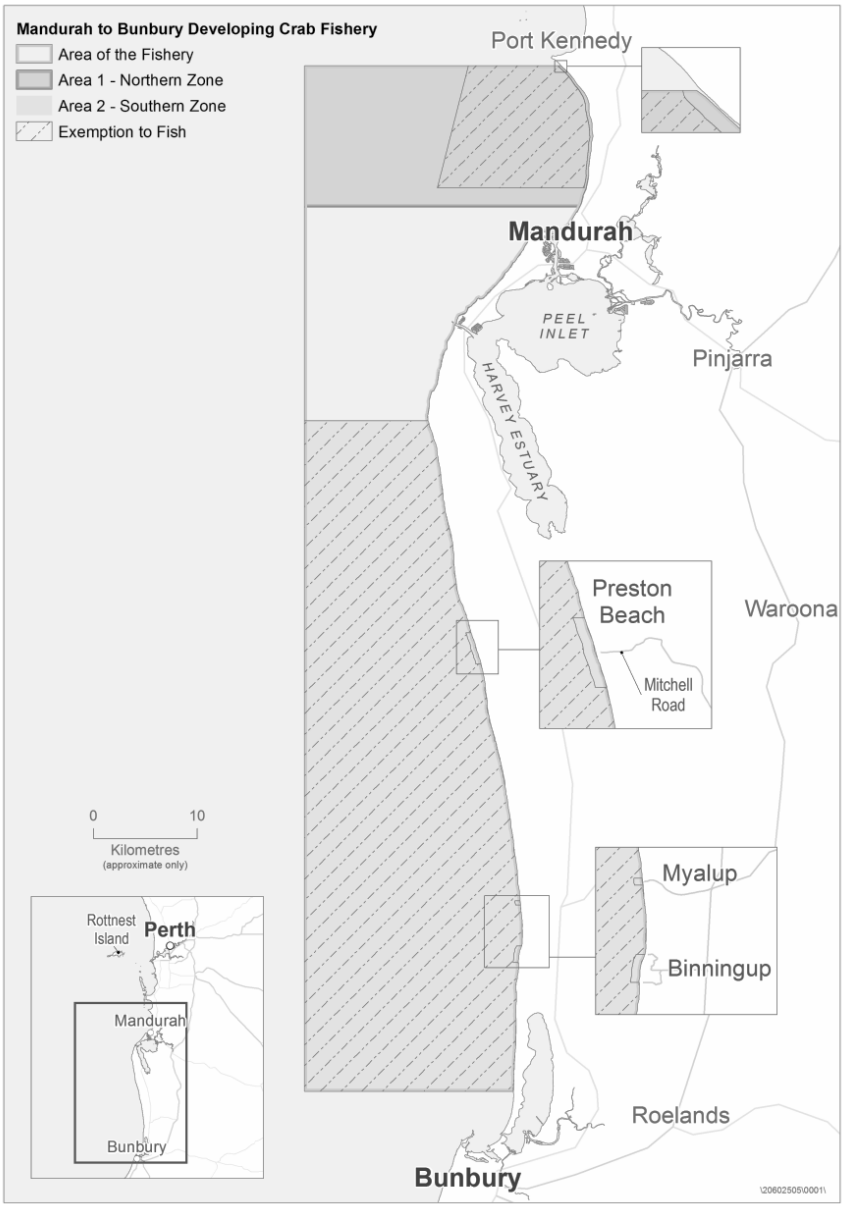


Figure 6.8 Boundaries of the commercial Mandurah to Bunbury Developing Crab Fishery and its Management Areas indicating Area 1 (Comet Bay) in the northern zone and Area 2 (Mandurah to Bunbury) in the southern zone.

6.2.2.3 Fishing Methods and Gear

Fishers in the MBDCF use purpose-designed, baited hourglass crab traps to target blue swimmer crabs (refer to Section 6.2.1.3 for detail).

6.2.2.4 Susceptibility

The blue swimmer crab assemblages in the MBDCF are highly likely to be the same genetic stock. Thus for the purposes of Productivity and Susceptibility Analysis (Section 9.3.6), these will be deemed a single stock.

Area 1 (CB) of the MBDCF covers ~121 km^2, with a high proportion of this area being suitable habitat for blue swimmer crabs. Due to the spatial distribution of this stock within the embayment and the expansive area fished by the commercial sector, areal overlap in Area 1 is likely to be high (>30%). Although Area 2 (MB) of the MBDCF covers ~958 km^2, only a narrow strip of coastal water (< 1 km from shore) provides suitable habitat for blue swimmer crabs. Consequently, areal overlap in Area 2 is likely to be high (>30%).

As the purpose-designed baited hourglass crab traps used in the MBDCF are set on the sea bed, the encounterability with the blue swimmer crab stock is high as they are primarily a benthic dwelling species. However, vertical overlap is considered moderate as the mesh size and escape gaps used in this fishery enable the majority of undersize crabs to escape capture.

Blue swimmer crabs can survive out of water for up to several hours provided their gills remain moist. As regulations stipulate the commercial fisher in the MBDCF must return berried and undersize crabs to the water within 5 minutes of being landed, post-capture mortality of non-retained catch with and without exposure to ice-slurries is low (Bellchambers *et al*., 2005; Leland, 2014; Uhlmann *et al*., 2009).

6.2.3 Leschenault Estuary

6.2.3.1 History of Development

The Leschenault Estuary (LE) is located immediately north of Bunbury in southwest WA (Figure 6.9). The estuary is micro-tidal and permanently open to the ocean via an anthropogenically modified entrance channel, and comprises a large shallow basin that rarely exceeds 2 m in depth, surrounded by a very shallow (≤0.5 m) fringing platform (Potter *et al.*, 2001). The basin measures 13.5 km in length and 1.5-2.5 km in width, with a short and narrow entrance channel towards the southern end that links the estuary with the nearshore marine environment (Figure 6.9).

Commercial fishing has taken place in the LE since the 19th century (Lenanton, 1984), with as many as 21 vessels operating in the fishery at any one time (Potter and de Lestang., 2000). Commercial fishers set gill/haul nets to target a variety of fish species, but also retained blue swimmer crabs as by-product. As with most fisheries in southwest WA, crab catches varied in line with environmental conditions, ranging from 1.3-9.8 t between 1987/88 and 1997/98 (Figure 6.10).

A pattern of declining catches through the late 1970s (Figure 6.10) along with increased urban development in the region saw commercial fishing areas, practices and resource-sharing issues increasingly become the subject of community interest. Commercial effort began to decline in the early 1980s, primarily in response to the intensifying level of conflict with the recreational fisheries sector (Lenanton, 2003). Various regulatory tools and adjustment mechanisms were applied to modulate the commercial catch, with the number of endorsements falling from 18 in 1979 to just six by the end of 1998 (Figure 6.10). A VFAS introduced in 2000/01 led to the removal of all commercial fishing effort from the LE, with the remaining six fishers surrendering their licences in 2001.

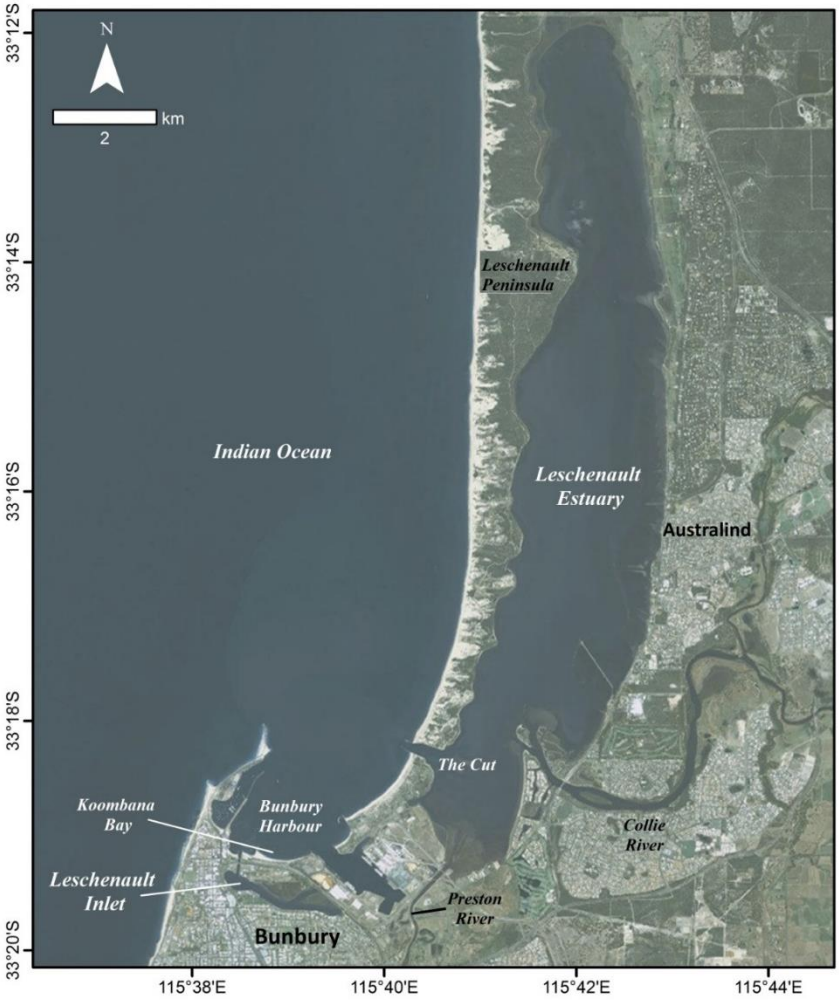


Figure 6.9 Aerial image of the Leschenault Estuary and wider Bunbury area.

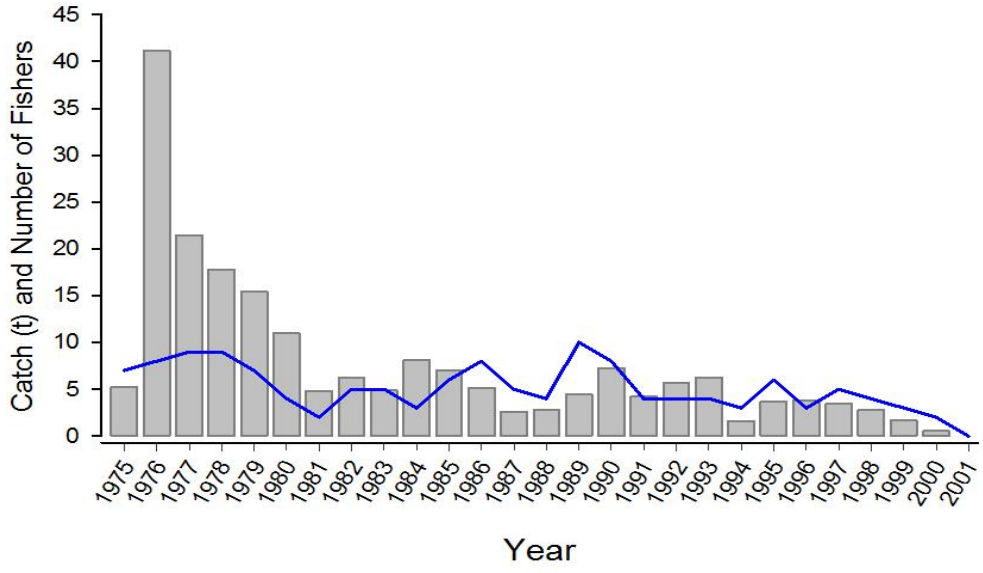


Figure 6.10 Annual commercial blue swimmer crab catch (t), and number of commercial fishers reporting crab catch, for the Leschenault Estuary between 1975 and 2001. The commercial fishery closed in 2001.

6.2.3.2 Current Fishing Activities

Commercial fishing in LE ceased in 2001.

6.2.4 Geographe Bay

6.2.4.1 History of Development

GB is located approximately 250 km south of Perth. The north-facing bay, which marks the southern end of the Swan Coastal Plain, provides a shallow marine environment that is relatively protected from the prevailing south-westerly swell by Cape Naturaliste to the west (Figure 6.11). It covers an area of approximately 290 nm^2 between the north-west point of Cape Naturaliste and the lighthouse at Bunbury Breakwater (Bellchambers *et al*., 2006).

Until its closure in 2005, GB was the southernmost dedicated commercial blue swimmer crab fishery on the WA coast (Borg and Campbell, 2003). While all licenced WA commercial fishers were permitted to set commercial drop nets in the waters of GB, only 12 commercial fishers had a demonstrated history of landing blue swimmer crabs from these waters. Furthermore, only six of these fishers identified themselves as genuine crab fishers, landing the majority of the commercial crab catch (Borg and Campbell, 2003).

As with most WA commercial crab fisheries, annual catches in GB varied considerably in line with fishing effort and changes to stock abundance in response to fluctuations in environmental conditions. The annual catch of blue swimmer crabs from GB increased from < 2 t in the early 1990s to a peak of 17 t in 1997, fluctuating between 7-15 t from 1998 to 2004 (Figure 6.12).

However, a significant increase in both urban development and tourist visitor numbers from the 1980s led to considerable debate over issues associated with commercial and recreational crab fishing in the communities adjacent to GB, and in particular the Busselton area. Despite two Department of Fisheries (DoF) surveys that estimated recreational crabbing catch and effort in 1996/97 (Sumner and Williamson, 1999) and 2000/01 (Sumner and Malseed, 2004) indicating otherwise, much of this discussion revolved around the perception that commercial fishers took a large part of the crab resource, leaving little for local recreational fishers and tourists (Borg and Campbell, 2003).

Following extensive community consultation, temporary management arrangements were introduced in May 1999 that:

- prohibited commercial fishing for crabs on weekends, public holidays and school holidays (other than the two-week school holiday at the end of the second school term in June each year);
- prohibited commercial gear being in the water from one hour after sunrise to one hour before sunset on all remaining days;
- prohibited commercial crabbing within a scheduled area covering the Busselton Jetty and its surrounding area.

However, these arrangements proved unsatisfactory to some members of the public and the commercial fishing sector. Further consultation, primarily in the form of the Geographe Bay Crab Mediation Group, led to a settlement agreement in December 2002 that ratified the

temporary management arrangements and imposed further minor restrictions on both commercial and sectors. Despite this agreement, conflict between the sectors remained and the commercial fishery was closed in January 2005.

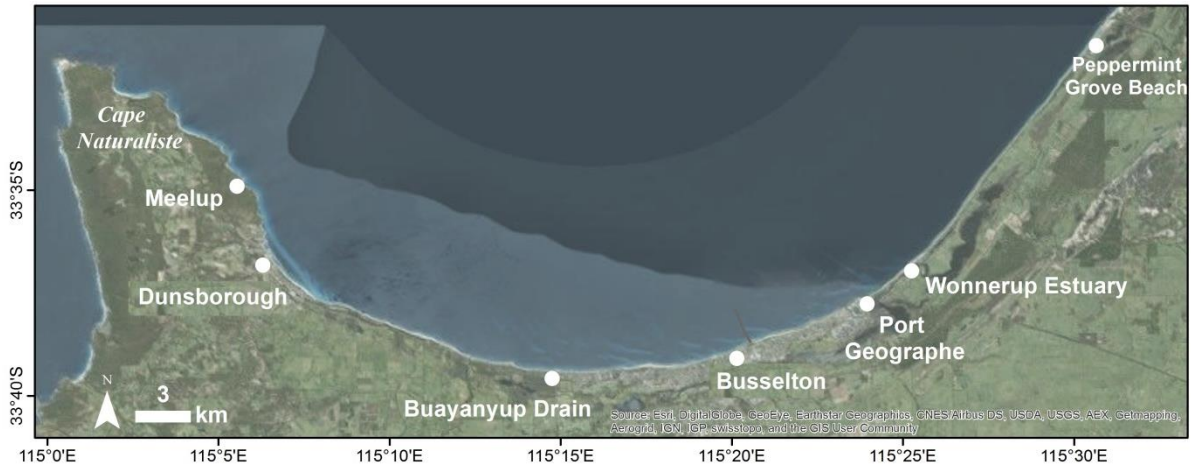


Figure 6.11 Aerial image of Geographe Bay.

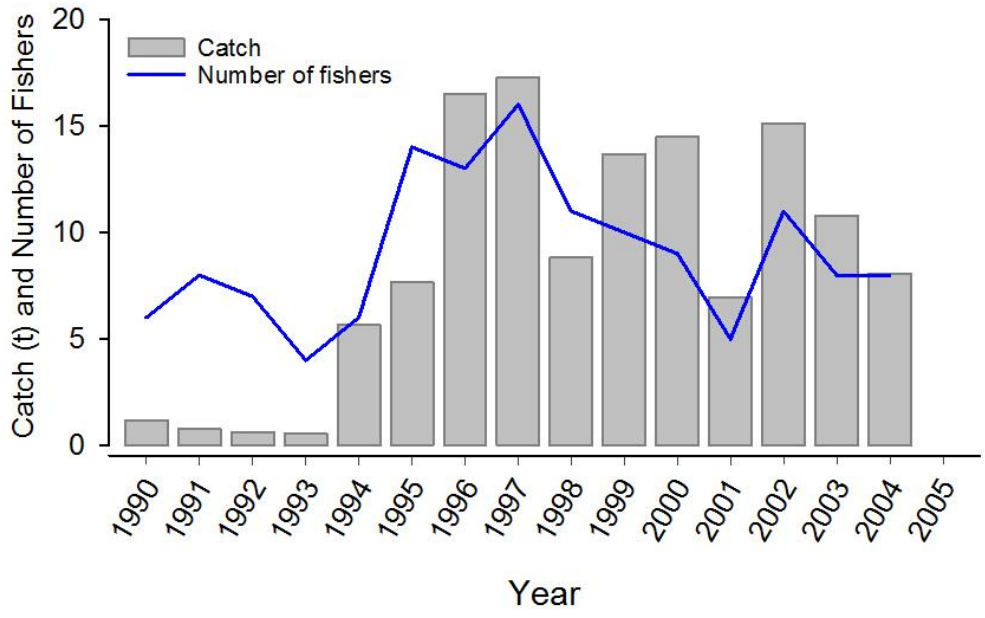


Figure 6.12 Annual commercial blue swimmer crab catch (t), and number of commercial fishers reporting crab catch, for Geographe Bay between 1990 and 2004. The commercial fishery closed in 2005.

6.2.4.2 Current Fishing Activities

Commercial fishing in GB ceased in January 2005.

6.2.5 Hardy Inlet

6.2.5.1 History of Development

The Hardy Inlet (HI) is located near the town of Augusta in south-western WA, approximately 300 km south of Perth. While commercial fishing in HI was endorsed by licence condition until

2014, the fishery is now managed as Area 3 of the WCEMF. A Fisheries Adjustment Scheme in 1998 resulted in a reduction from nine fishers to one (DoF, 2004). The remaining commercial fisher uses set nets to target finfish (primarily yellowfin whiting *Sillago schomburgkii* and sea mullet *Mugil cephalus*), and retains blue swimmer crabs as a by-product. Landings of blue swimmer crabs from HI were first reported in 2005, with annual catches (<1.3 t) minimal compared to other WA fisheries.

Following a submission in 2015, a three-year Instrument of Exemption was issued to trial (a maximum of 20) purpose-designed crab traps to target blue swimmer crabs in HI. The Exemption, which stipulates that the fisher must not fish for blue swimmer crabs by any means other than crab traps during the period of the trial, was extended to July 2021. However, commercial trap catch and effort during the trial has been minimal.

6.2.5.2 Current Fishing Activities

A summary of key attributes of Area 3 (HI) of the WCEMF is provided in Table 6.4.

The fishery encompasses the waters of the HI together with the Blackwood River and all its tributaries upstream of the mouth of the HI, and restricted waters of Flinders Bay (Figure 6.13). Refer to the WCEMF Management Plan 2014 for details of specific fishery boundaries and management areas.

Table 6.4 Summary of key attributes in Area 3 of the West Coast Estuarine Managed Fishery (The Hardy Inlet).

Attribute	
Fishing methods	Set nets and crab traps
Fishing capacity	800m set net; 20 traps
Number of licences	1 (active)
Number of vessels	1
Size of vessel	5 m
Number of people employed	1
Value of fishery	< $0.1 million; (2018/19 year GVP at $6.16/kg); Level 1

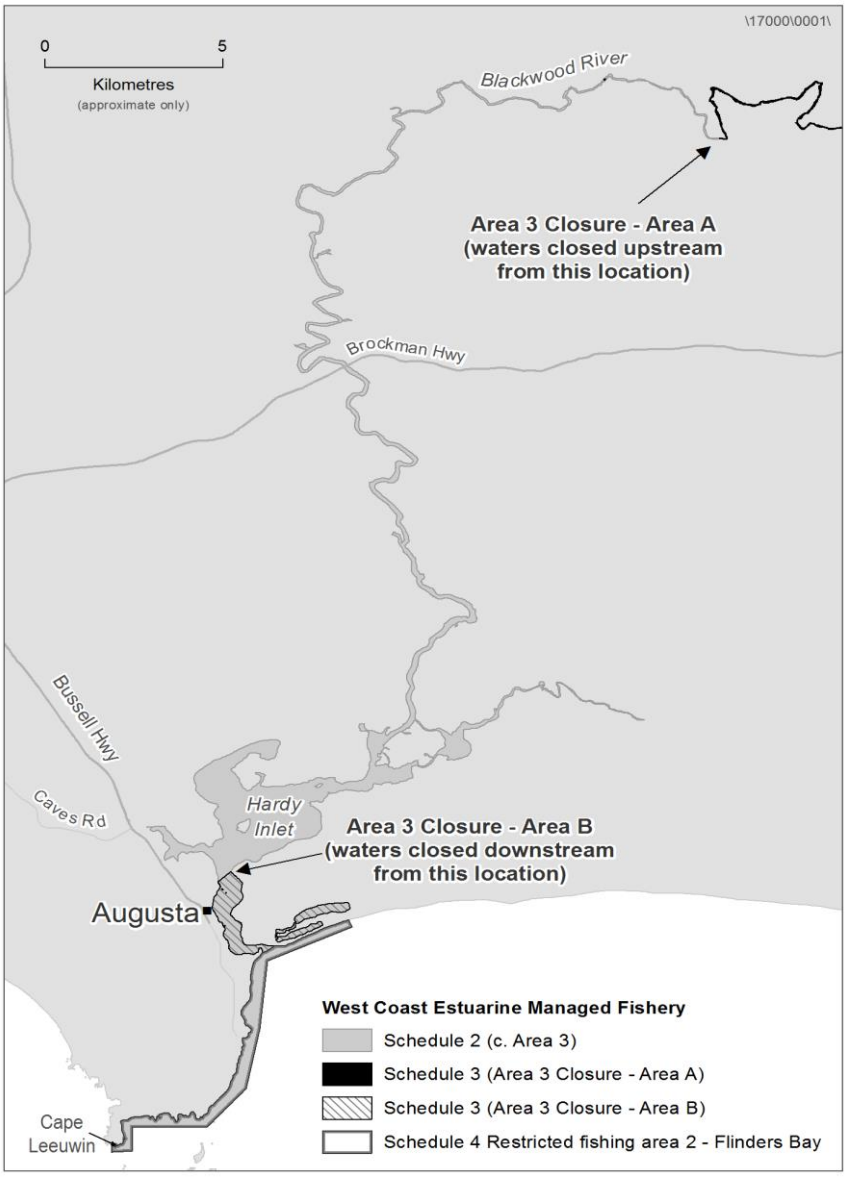


Figure 6.13 Boundaries of Area 3 of the West Coast Estuarine Managed Fishery (The Hardy Inlet) and its closed areas.

6.2.5.3 Fishing Methods and Gear

The commercial fisher in HI is endorsed to use 800 m of set net and 20 purpose-designed crab traps per day. Each trap can only be pulled once in a 24-hour period.

As the current trap Exemption is exploratory, the only limitations put on trap design are:

i. A crab pot must not have an internal volume of more than 0.31 m^3; or

ii. In the case of a cylindrical trap, must not have a diameter of more than 1 m.

Traps are baited with species of fish caught during the fisher's netting activities.

6.2.5.4 Susceptibility

For the purposes of Productivity and Susceptibility Analysis (Section 9.3.6), blue swimmer crabs in HI will be deemed a single stock.

Most of the waters covered by Area 3 of the WCEMF is suitable habitat for the blue swimmer crab. As the commercial fishery operates in the majority of these waters, areal overlap is likely to be > 30%.

The gill nets used in Area 3 of the WCEMF are demersal and have a vertical height of approximately 1 m from the substrate. Crab traps also sit on the benthos. As blue swimmer crabs are primarily a benthic dwelling species, encounterability is likely to be high.

Blue swimmer crabs can survive out of water for up to several hours. As the commercial fisher in HI must return berried and undersize crabs to the water within 5 minutes of being landed, post-release mortality rates of non-retained catch with and without exposure to ice-slurries are low (Bellchambers *et al*., 2005; Broadhurst and Millar, 2018; Leland, 2014; Uhlmann *et al*., 2009).

6.3 Recreational Fishery

6.3.1 History of Development

Blue swimmer crabs represent one of the most important recreationally-fished inshore species in WA, with most recreational fishing occurring in the WCB (Ryan *et al*., 2019). A national survey of recreational and indigenous fishing was conducted in Australia during 2000-01 by Henry and Lyle (2003). Blue swimmer crabs represented the most numerous of the crabs taken by recreational fishers, with a national harvest of approximately 3.9 million crabs (Henry and Lyle, 2003). Harvest levels were greatest in WA (57% of total). More recent recreational catch statistics for WA crab fisheries have been gathered through 'iSurveys' conducted biannually since 2011/12 (see Section 6.3.2 below).

Recreational crab fisheries in the WCB are centred largely on the estuaries and coastal embayments from GB to the SCE, with the PHE being the largest. Management arrangements for the commercial and recreational fisheries include minimum size, protection of breeding females and seasonal closures with effort controls in place for the commercial fishery (Johnston *et al*., 2015a).

The State minimum legal recreational size limit is set at 127 mm CW, which is substantially above the size at 50% maturity for blue swimmer crabs in WA (see Section 5.3.2 in Johnston *et al*., 2020b). Further protection is provided to the breeding stock through a ban on berried females and a seasonal closure during the peak spawning period from September to November introduced in 2019.

Recreational fishers have a daily bag limit of 10 crabs per fisher per day in the WCB, which was decreased from a limit of 20 prior to November 2007. Recent changes implemented in December 2019 include a maximum of five females out of the total 10-bag limit in GB, as an additional measure to protect female breeding stock.

There is no specific recreational crabbing licence in WA, however, crabbers fishing from a powered vessel have required a Recreational Fishing from Boat Licence (RFBL) since March 2010. There is currently a daily boat limit of 20 crabs, provided there are two or more people on-board holding RFBLs.

Recreational surveys specifically for the LE and GB have provided information on both boat- and shore-based fishing effort and catch of blue swimmer crabs. However, they were typically limited to daylight fishing and may have underestimated the total recreational catch.

Leschenault Estuary

The LE is one of the most popular estuaries for recreational fishing in southwest WA, with blue swimmer crabs the most targeted recreational species in this estuary (Malseed *et al.*, 2000).

Malseed *et al.* (2000) conducted a 12-month survey of recreational boat-based and shore-based fishing in the LE in 1998 reporting around 87% of the recreational effort was targeted at blue swimmer crabs, which accounted for 98% of the total recreational catch for the year. The survey estimated a total annual recreational catch of 219,000 blue swimmer crabs, or 45.7 tonnes, with approximately 80% of the retained catch being male. Boat-based fishers accounted for more than 80% of the catch. The majority of the recreational crabbing effort occurred over the summer months, accounting for 70% of boat-based fishing and 82% of shore-based fishing. Autumn and spring were the next most popular seasons, with very little crabbing taking place during winter (Malseed *et al.*, 2000). These seasonal fluctuations in crabbing effort and catch rates reflect seasonal changes in water temperatures. Potter and de Lestang (2000) reported crab numbers in the estuary peaked from late spring through summer and early autumn, when salinities and water temperatures are highest. Crab numbers decline from late autumn, with the majority leaving the estuary as winter rainfall increases and salinity and water temperature decline.

More recent recreational catch statistics for WA crab fisheries have been gathered through ‘iSurveys’ conducted biannually since 2011/12. However, these surveys have not reported the fine-scale spatial resolution necessary to provide estimates of recreational crabbing catch and effort in the LE.

Geographe Bay

Fishing for blue swimmer crabs is one of the most popular pastimes for locals and tourists in GB (Borg and Campbell, 2003). However, the fishery differs from other southwest WA crab

fisheries in that most fishing effort, and the highest catch rates, occurs over the winter/spring months between July and November when the catch is predominantly female (Sumner and Malseed, 2004). The fishery is further characterised by crabbing occurring almost exclusively in waters less than 200 m from the shore (Borg and Campbell, 2003).

A creel survey of recreational boat-based fishers on the west coast of WA from Augusta to Kalbarri between September 1996 and August 1997 reported a boat-based blue swimmer catch from GB of 17.5 t (Sumner and Williamson, 1999).

A creel survey undertaken by Sumner and Malseed (2004) in GB between December 2001 and November 2002 estimated recreational boat and shore-based catch and effort to be 28.6 t from 21,500 fisher days for that period, with the majority (27.0 t from 19,400 fisher days) taken by boat-based fishers. Spring (Sep-Nov) was the most popular season for crabbing in GB, accounting for 54% of the boat-based effort and 52% of shore-based effort. Furthermore, the period from July to November contributed 82% of the catch. Female crabs dominated the catch over the surveyed period, comprising 81% of the retained catch and 72% of the released catch. The most popular area for crabbing was in the vicinity of the Port Geographe Marina and from the Busselton Jetty east to the Wonnerup Estuary.

6.3.2 Current Fishing Activities

Recreational fishing for blue swimmer crabs is undertaken in waters of the SCE, Cockburn Sound (CS), WS, the PHE, the LE, and GB, where they dominate the inshore recreational catch. Highest recreational catches are taken from the PHE followed by the SCE and GB.

In 2017-18, total boat-based recreational catch of blue swimmer crabs for WA was estimated to be 61.1 t, of which 88.5% or 54.1 t (95% CI 45–63 t) was taken from the WCB (1.57 t from the North Coast, 5.36 t from the Gascoyne and 0.078 t from the South Coast bioregions) (Ryan *et al*., 2019). This 2017/18 estimate for the WCB was similar to that of 2015/16 (44 t, 95% CI 36–50 t) and 2013/14 (59 t; 95% CI 50–68 t), but notably lower than during 2011/12 (87 t. 95% CI 75–97 t; Ryan *et al*., 2019).

Since 2013, a recreational voluntary logbook program, the Research Angler Program (RAP), has provided data on catch and effort in the SCE, LE and GB (Harris *et al*., 2017). This has allowed assessment of the recreational fishery through monitoring of catch rates and size composition over time.

6.3.3 Fishing Methods and Gear

Regulations govern the methods recreational fishers can use to fish for blue swimmer crabs in WA. Crabs may only be caught by hand (*e.g.* while diving and snorkelling), using hand-held wire or plastic scoop nets, drop nets or hand-held blunt wire hooks (not capable of piercing the crab). Scoop nets must be bowl-shaped and made of rigid mesh not capable of entangling a crab (Figure 6.14). Scoop nets must be no deeper than 210 mm and the internal diameter must be no greater than 375 mm. Drop nets must be no more than 1.5 m in diameter (Figure 6.14). There is a maximum limit of 10 drop nets per person when fishing from the shore, or 10 drop nets per boat, regardless of how many people are on board.

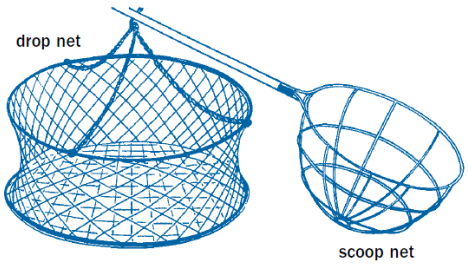


Figure 6.14 Drop and scoop nets employed by recreational fishers for blue swimmer crabs.

6.3.4 Susceptibility

For the purposes of the Productivity Analysis (PSA, Section 9.3.6), the blue swimmer crab assemblages in the WCB coast have been divided into two major stocks; one encompassing CS and SCE, while the other includes WS, PHE, the coastal waters of CB and MB, the LE, GB and the HI.

Areal overlap using scoop netting in the second west coast stock other than in PHE is relatively low (~ <10%), due to the small area available to shore-based scoop netters. However, due to the boat-based nature of drop nets the areal overlap is higher (~10-30%).

Encounterability of recreational fishing methods in all stocks is high as methods used specifically target blue swimmer crabs. Selectivity attributed to recreational fishers is considered moderate. Although undersize or berried female crabs are often caught by recreational drop net fishers, divers and scoop netters actively avoid them. Post-capture mortality is generally low as recreational fishers are required to return undersize and berried females to the water within 5 minutes of being landed.

6.4 Customary Fishing

There is currently no customary fishing of the blue swimmer crab resource in the WCB.

6.5 Illegal, Unreported or Unregulated Fishing

Management arrangements for the south-west crab fisheries are enforced regularly by the Department's Fisheries and Marine Officers. Compliance is monitored via both sea and land-based inspections, with the majority of checks being carried out on land at the point of landing (boat ramps).

Compliance by the commercial sector is generally high, however illegal fishing activities by the recreational sector are a risk to some fisheries. The Peel-Harvey recreational crab fishery has a high level of enforcement risk with one of the highest levels of non-compliance in the State, particularly for retention of undersize crabs during night-time periods (Johnston *et al*., 2015a). Compliance effort in the PHE, in terms of overall presence of Fisheries Officers and the number of contacts made with fishers, has remained similar since 2014/15 (Johnston *et al*., 2015b - Addendum 2019). Although retention of undersized crabs remains the main offence type in the recreational crab fishery, the number of prosecution briefs, infringement notices and warnings recorded in 2017/18 were all lower than the previous year. Although this, coupled

with the stable compliance effort, suggests that the level of non-compliance in this fishery has declined, these data are likely to be heavily influenced by changes in the abundance and availability of crabs between years (Johnston *et al*., 2015b - Addendum 2019). The introduction of a season closure extension to include November in 2020, will reduce the capture of undersize crabs which are prevalent in the fishery at this time.

7. Fishery Management

7.1 Management System

The harvest strategy for the blue swimmer crab resource of Western Australia (WA) is essentially a constant exploitation approach, where the annual catch varies in proportion to variations in stock abundance. To implement this strategy, commercial and recreational fisheries capturing crabs are managed using a range of input controls. Commercial fishing effort is constrained by a cap on the number of licences/vessels operating in each fishery (limited entry) and restrictions on fishing gear, including the number and size of crab traps, and the length of nets. Recreational fishing effort is managed by gear controls (e.g. limits on the number of drop nets used) and daily bag and boat limits. Recreational fishers operating from a boat are required to hold a current Recreational Fishing from Boat Licence (RFBL). Other restrictions include retainable species, minimum size limits (commercial 127 – 130 mm CW, recreational 127 mm CW) and spatio-temporal fishing closures (e.g. during spawning seasons).

7.2 Harvest Strategy

A harvest strategy for the blue swimmer crab resource in the West Coast Bioregion (WCB) outlines the long and short-term objectives for management (DPIRD, 2020; Table 7.1). It also provides a description of the performance indicators used to measure performance against these objectives, reference levels for each performance indicator, and associated control rules that articulate pre-defined, specific management actions designed to maintain the resource at target levels.

The status of the blue swimmer crab resource in the WCB is assessed annually using a weight-of-evidence approach of all available data for the key areas in which the resource is commercially targeted. As genetic studies have indicated that blue swimmer crabs in these estuaries are genetically distinct, these fisheries are currently monitored and assessed separately. Due to a lack of information about the total recreational effort and catch of blue swimmer crabs in individual fisheries of the WCB, harvest strategy for these stocks is primarily based on standardised commercial catch rates relative to reference levels.

For each area, reference levels have been calculated from the standardised catch rates observed annually during a reference period of relative stability when the fishery was considered to have been operating sustainably (Warnbro Sound – 2004/05-2011/12, Comet Bay; CB – 2006-12, Mandurah to Bunbury; MB – 2004-12). The target range extends between the maximum and minimum values recorded during that reference period, where the latter denotes the threshold

level assumed to represent a proxy for the stock level at which Maximum Sustainable Yield (MSY) can be achieved. Any stock size above this level is therefore consistent with meeting the objectives for biological sustainability and also satisfy stock status requirements under the Marine Stewardship Council (MSC) standard for sustainable fishing. A conservative approach has been taken to set the limit reference level at 70% of the threshold value (*i.e.* $0.7B_{MSY}$) and is considered to represent the level below which recruitment may be impaired (DPIRD, 2020).

Abundance information for blue swimmer crabs in the Warnbro Sound Crab Managed Fishery (WSCMF) and Areas 1 (CB) and 2 (MB) of the Mandurah to Bunbury Developing Crab Fishery (MBDCF) is also derived from commercial monitoring surveys that inform broader weight-of-evidence assessments of these stocks (see Section 9.3). It is anticipated that fishery-independent indices from breeding stock surveys may be used as performance indicators in future harvest strategies for the Leschenault Estuary (LE) and Geographe Bay (GB), once sufficient time series of data are available.

Table 7.1. Harvest strategy performance indicators, reference levels and control rules for the blue swimmer crab resource of south-west WA (Warnbro Sound Crab Managed Fishery and Area 1 (Comet Bay) and Area 2 (Mandurah to Bunbury) of the Mandurah to Bunbury Developing Crab Fishery).

Component	Management objectives	Resource / Asset	Performance Indicators	Reference Levels	Control Rules
Target species	To maintain spawning stock biomass of blue swimmer crabs at a level where the main factor affecting recruitment is the environment	Blue swimmer crabs in south-west WA	Annual standardised commercial catch rate in: 1. Warnbro Sound 2. Area 1 of the Mandurah to Bunbury Developing Crab Fishery (Comet Bay) 3. Area 2 of the Mandurah to Bunbury Developing Crab Fishery (Mandurah to Bunbury)	**Target:** Warnbro Sound: 0.79 – 1.7 kg/traplift Comet Bay: 0.54 – 0.9 kg/traplift Mandurah to Bunbury: 1.56 – 2.2 kg/traplift	Continue management aimed at achieving ecological, economic and social objectives.
				Threshold: Warnbro Sound: 0.79 kg/traplift Comet Bay: 0.54 kg/traplift Mandurah to Bunbury: 1.56 kg/traplift	If the threshold level is breached, a review will be completed within three months to develop an appropriate management response. Management action (applicable to all relevant fisheries/sectors) will be taken to reduce catches by up to 50%[1] of the current harvest level to return stock to the target level.
				Limit: Warnbro Sound: 0.55 kg/traplift. Comet Bay: 0.38 kg/traplift Mandurah to Bunbury: 1.09 kg/traplift	If the limit level is breached, management action (applicable to all relevant fisheries/sectors) will be immediately taken to reduce catches by at least 50% of the current harvest level. A review will be completed within three months to determine what additional management actions (up to 100% catch reduction[5]) are required to rebuild the stock to the target level within two generation times (*i.e.* informing the recovery strategy for the stock).

[1] The level of catch reduction to the relevant fisheries/sectors will be dependent on the extent by which the reference level has been breached, and the required rebuilding rate.

7.2.1 Warnbro Sound Crab Managed Fishery

The primary performance indicator for the WSCMF harvest strategy is standardised catch rate (CPUE in kg/traplift) over the fishing season, using the reference period 2004/05-2011/12 (Table 7.1). The reference period covers the period when the previous operator fished, during which the target (range between the threshold and highest historical catch rate), threshold (lowest historical catch rate), and limit (30% below the lowest catch rate) were set. Catch rate is standardised for month and year. Performance indicators and harvest strategies will be reviewed when the commercial fishery ceases to operate.

7.2.2 Mandurah to Bunbury Developing Crab Fishery

The primary performance indicator for the harvest strategy for Area 1 and Area 2 of the MBDCF, is nominal annual catch rate (CPUE in kg/traplift) (Table 7.1). The reference period is defined as the period between 2006 and 2012 for Area 1 (CB), and 2004 and 2012 for Area 2 (Mandurah-Bunbury) during which the target (range between the threshold and highest historical catch rate), threshold (lowest historical catch rate), and limit (30% below the lowest catch rate) were set. Performance indicators and harvest strategies will be reviewed when the commercial fishery ceases to operate.

7.2.3 Area 3 of the West Coast Estuarine Managed Fishery (Hardy Inlet)

As commercial fishing for blue swimmer crabs in the Hardy Inlet (HI) has been minimal, a harvest strategy for this fishery has yet to be developed as there has not been a suitable period of relative stability in catch and effort to set appropriate reference levels. Until a harvest strategy is developed, commercial catch, effort and nominal catch per unit effort (CPUE) for both the trap and net sectors will be used in a Weight of Evidence approach to assess the crab resource.

7.3 External Influences

External influences include other activities and factors that occur within the aquatic environment that may or may not impact on the productivity and sustainability of fisheries resources and their ecosystems. The main external influences included here are environmental factors and market influences.

7.3.1 Environmental Factors

As a short-lived, invertebrate species, environmental factors are presumed to have a strong influence on the blue swimmer crab resource. Recent analyses have demonstrated that a number of environmental variables, including water temperature, rainfall, salinity and lunar phase can influence commercial catch rates (Johnston *et al*., 2020b), and changes in temperature and primary production may also be linked to declines in recruitment, growth and overall abundance (Marks et al., 2020). Given that the crab resource is, at any given time, essentially comprised of only two cohorts (Marks et al., 2020), environmental perturbations could be expected to result in major fluctuations in population size.

7.3.1.1 Climate Change

A risk assessment of WA's key commercial and recreational finfish and invertebrate species has demonstrated that climate change is having a major impact on some exploited stocks (Caputi *et al*., 2015). This is primarily occurring through changes in the frequency and intensity of ENSO events, decadal variability in the Leeuwin Current (LC), increase in water temperature and salinity, and change in frequency and intensity of storms and tropical cyclones affecting the state (Caputi *et al*., 2015). In 2010/11, a very strong LC resulted in unusually warm ocean temperatures in coastal waters of south-western WA (Pearce *et al*., 2011). This "marine heatwave" altered the distribution and behaviour (e.g. spawning activity and migration) of some species and caused widespread mortalities of others such as blue swimmer crabs in Shark Bay resulting in the collapse of this fishery (Chandrapavan *et al*., 2018; 2019).

A risk screening of WA's key commercial and recreational finfish and invertebrate species revealed *P. armatus* to have a high overall sensitivity to climate change (Caputi *et al*., 2015). Many of the biological processes of crabs are highly influenced by environmental variables, suggestive of a high sensitivity to climate change. The effects of climate change are likely to differ between blue swimmer crab fisheries in WA, based on the large latitudinal range between crab fisheries.

7.3.2 Introduced Pest Species

The introduction and spread of marine pests in WA waters poses a serious threat to native biodiversity and can have widespread effects on both the economy and public health. The Asian paddle crab (*Charybdis japonica*) has the potential to outcompete native species such as the blue swimmer crab if it becomes established in Australia. A biosecurity program is run by the Department of Primary Industry and Regional Development (DPIRD) to record sightings of the Asian paddle crab, with only very small numbers reported sporadically in south-western Australia to date.

7.3.3 Market Influences

Markets for blue swimmer crabs have been established for decades due to its popularity, with fishing dating back to the 1800s in the Swan-Canning Estuary (SCE). Southwest WA blue swimmer crab fisheries sell the majority of their product on the domestic market within WA, although a small number of fishers are exploring markets on the East Coast. The value of each fishery is therefore strongly influenced by local demand. In these small fisheries, fishers often fish to meet orders which influences catch and effort. Demand for product is generally consistent between years, with peak demand over summer-autumn.

8. Information and Monitoring

8.1 Range of Information

A range of information is available to support the assessment and harvest strategies for the blue swimmer crab resource in the Warnbro Sound Managed Crab fishery (WSCMF), the Mandurah to Bunbury Developing Crab Fishery (MBDCF), the Leschenault Estuary and wider Bunbury area (LE), Geographe Bay (GB) and the Hardy Inlet (HI) within the West Coast bioregion (WCB; Table 8.1).

Table 8.1 Summary of information available for assessing the blue swimmer crab resource in the Warnbro Sound Crab Managed Fishery (WSCMF); Areas 1 (Comet Bay; CB) and 2 (Mandurah to Bunbury) of the Mandurah to Bunbury Developing Crab fishery (MBDCF), the Leschenault Estuary (LE), Geographe Bay (GB) and Area 3 (the Hardy Inlet: HI) of the West Coast Estuarine Managed Fishery (WCEMF).

Data type	Fishery-dependent or independent	Purpose / Use	Area of collection	Frequency of collection	History of collection
Commercial catch and effort statistics (CAES returns)	Dependent	Monitoring of commercial catch and effort trends, calculation of catch rates and the area fished	WSCMF MBDCF HI	Monthly	Since 1987 Since 1993 Since 2005
Commercial monitoring Length-frequency estimates, catch rates	Dependent	Size structure and catch composition and catch rates for EPI (CSCMF)	WSCMF MBDCF	* Monthly	Since 2007 Since 2006
Logbook data	Dependent	Spatial, catch and effort, bycatch, sex ratios, catch composition & discards	MBDCF	Daily	Since 2004
Recreational catch and effort estimates	Dependent	Monitoring of recreational catch and effort trends through boat-based iSurveys and boat and shore-based creel surveys	West coast bioregion LE GB	iSurvey biennial Creel survey ad-hoc	Since 2011/12 1996/97 (WCB/GB) 1998 (LE) 2001/02 (GB)
Recreational angler logbook data	Dependent	Monitoring of recreational catch rates, catch composition	LE, GB	Daily	Since 2013
Spawning stock survey data	Independent	Catch rates provide an index of spawning stock abundance, and information on sex ratios and the reproductive stage of females	LE, GB	Annually	Since 2013
Biological information	Dependent and independent	Patterns of growth and reproduction (size at maturity & fecundity), length-weight, trap selectivity, tagging/movement	All fisheries, with a focus on CSCMF & PHE	As required	Since ~2007

*Frequency of collection is an approximation for the purpose of the summary table. Occasionally, sampling was carried out more or less frequently depending on circumstances. Fishery-specific details on sampling frequency can be found in Section 8.2.4.

8.2 Monitoring

8.2.1 Commercial Catch and Effort

All fishers operating in the WSCMF, MBDCF and HI (Area 3 of the West Coast Estuarine Managed Fishery; WCEMF) are required to submit monthly statutory catch and effort statistics (CAES). These data have been used to provide the basis for ongoing stock assessment and are critical to the development of stock performance indices and harvest strategy evaluation.

Under the *Fisheries Resource Management Act 1994*, licensees involved in fishing operations and/or the master of every licensed fishing boat must submit an accurate and complete monthly catch and effort return on forms approved by the Department. The returns record monthly catch totals (in kg) for each retained species, estimates of daily effort (*e.g.* number of traps pulled per day), spatial information by block (60 × 60nm) and bycatch/endangered and threatened species. These catch and effort returns are submitted monthly, with a deadline of 15 days after the end of the month. All CAES returns are validated by Departmental staff and any inconsistencies are further verified directly with fishers. The information provided in CAES returns is confirmed by processor unloads, which are also provided to the Department on a monthly basis.

These data are also validated by commercial monitoring information collected by Departmental research staff on-board commercial vessels throughout the fishing season.

8.2.2 Recreational/Charter Catch and Effort

A biennial state-wide recreational survey was implemented in 2011 to collect information on recreational catch and effort in WA (Ryan *et al*., 2013; 2015; 2017; 2019). This survey uses three complementary components, off-site phone diary surveys, on-site boat ramp surveys and remote camera monitoring, to collect information on fishing catch, effort, location and other demographic information, every two years. While the earlier three surveys focused on boat-based fishing, the latest 2017/18 survey also included shore-based recreational fishing.

These surveys provide a state-wide and bioregional estimate of the boat-based recreational catch; both kept and released. In each survey, state-wide on-site biological surveys were completed at key boat ramps to obtain length and weight information that would allow estimates of catch by numbers from the phone-diary surveys to be converted to catch by weight. This enables direct comparison of recreational harvest estimates to commercial fishery information, which is routinely recorded as weights.

Several surveys estimating recreational blue swimmer crab catch and effort have been undertaken over specific time frames in the LE (1998 – Malseed *et al*., 2000) and GB (1996/97 – Sumner and Williamson, 1999; 2001/02 – Sumner and Malseed, 2004).

Details and catch estimates for all recreational surveys are outlined in Section 9.3.2.

8.2.3 Fishery-Dependent Monitoring

Commercial monitoring

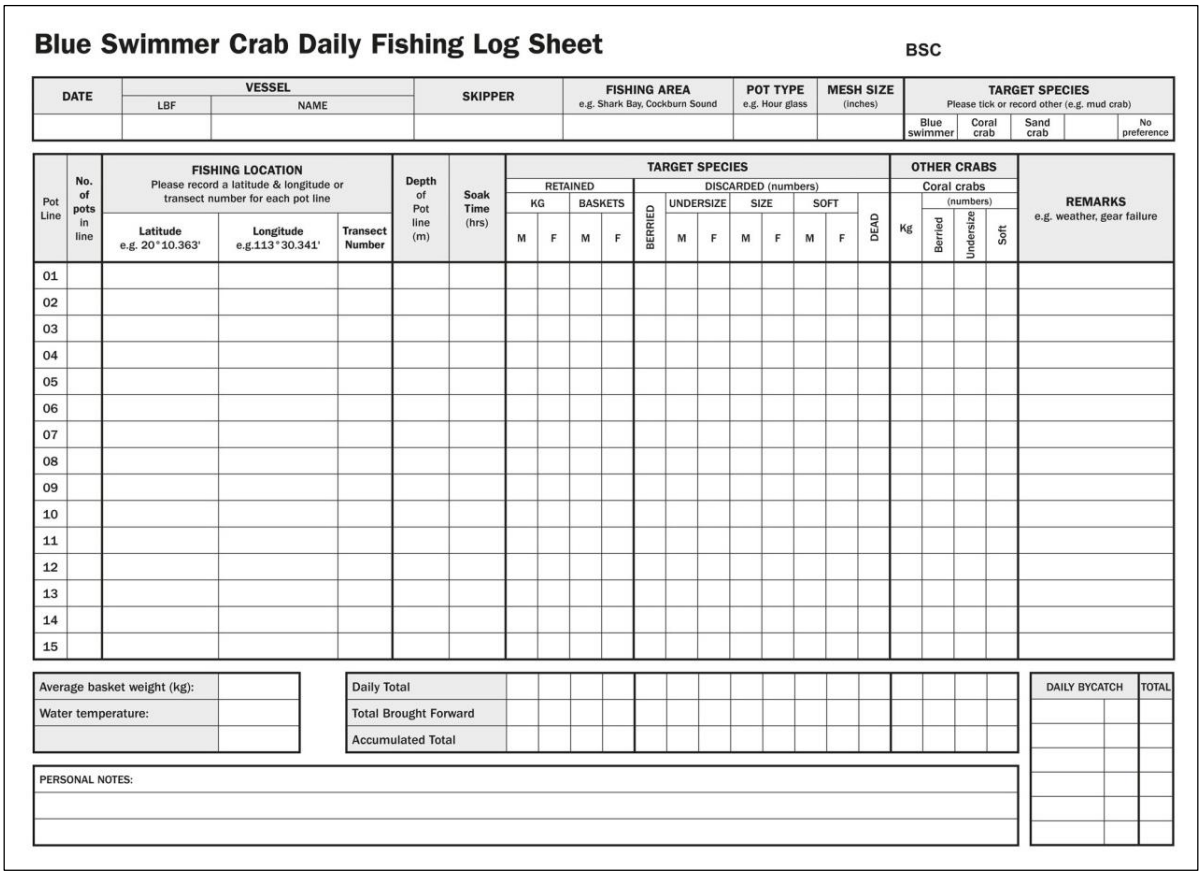
In addition to catch and effort data, Departmental research staff undertake monthly fishery–dependent monitoring on commercial vessels in the WSCMF and MBDCF. These surveys provide data on catch composition (size structure, catch composition, sex ratios, berried), abundance data used to calculate standardised legal catch rates, female size at maturity and spatial distribution of commercial fishing. During each survey, all crabs captured are measured to the nearest mm (CW; spine to spine) using Vernier calipers. Biological information, including sex, moult stage, sexual maturity status and berried state, are collected for each crab based upon visual examination (refer to Section 5.3.5 in Johnston *et al*., 2020b). Any bycatch, obvious predation (*e.g.* by octopus) or dead crabs are also recorded. Data is recorded per line of traps or length of net, and includes the number of traps or metres of net in the line, soak time (number of hours traps or nets have been in the water since last serviced), a start latitude and longitude and a mean depth.

Commercial daily research trap logbooks

Daily research trap logbooks were introduced as part of exemption requirements in the MBDCF to gain comprehensive (finer resolution) daily catch and effort data from commercial trap fishers (Figure 8.1). For each line of crab traps set, fishers are required to record a latitude and longitude or block reference, the number of traps in the line, depth, trap soak-time and a total catch estimate in either kilograms or baskets of crabs. If reporting in baskets, the fisher is to include an average basket weight to allow for the conversion of the basket estimate to a catch in kilograms for that line.

Logbook data are validated by comparing research log books with statutory monthly CAES returns, and spatially presenting fishing locations when transect grid numbers or latitude and longitude details are recorded by fishers. As with monthly CAES return requirements, fishers are required to submit monthly logbook returns by the 15th of the following month.

While efforts are being made to improve research logbook compliance by MBDCF fishers, the data submitted to date is not considered reliable and therefore has not been included in this report.



Blue Swimmer Crab Daily Fishing Log Sheet BSC

DATE	VESSEL LBF	VESSEL NAME	SKIPPER	FISHING AREA e.g. Shark Bay, Cockburn Sound	POT TYPE e.g. Hour glass	MESH SIZE (inches)	TARGET SPECIES Please tick or record other (e.g. mud crab)				
							Blue swimmer	Coral crab	Sand crab		No preference

Pot Line	No. of pots in line	FISHING LOCATION Please record a latitude & longitude or transect number for each pot line			Depth of Pot line (m)	Soak Time (hrs)	TARGET SPECIES												OTHER CRABS				REMARKS e.g. weather, gear failure
							RETAINED				DISCARDED (numbers)								Coral crabs				
							KG		BASKETS			UNDERSIZE		SIZE		SOFT				(numbers)			
		Latitude e.g. 20°10.363'	Longitude e.g.113°30.341'	Transect Number			M	F	M	F	BERRIED	M	F	M	F	M	F	DEAD	Kg	Berried	Undersize	Soft	
01																							
02																							
03																							
04																							
05																							
06																							
07																							
08																							
09																							
10																							
11																							
12																							
13																							
14																							
15																							

Average basket weight (kg):	
Water temperature:	

Daily Total																	
Total Brought Forward																	
Accumulated Total																	

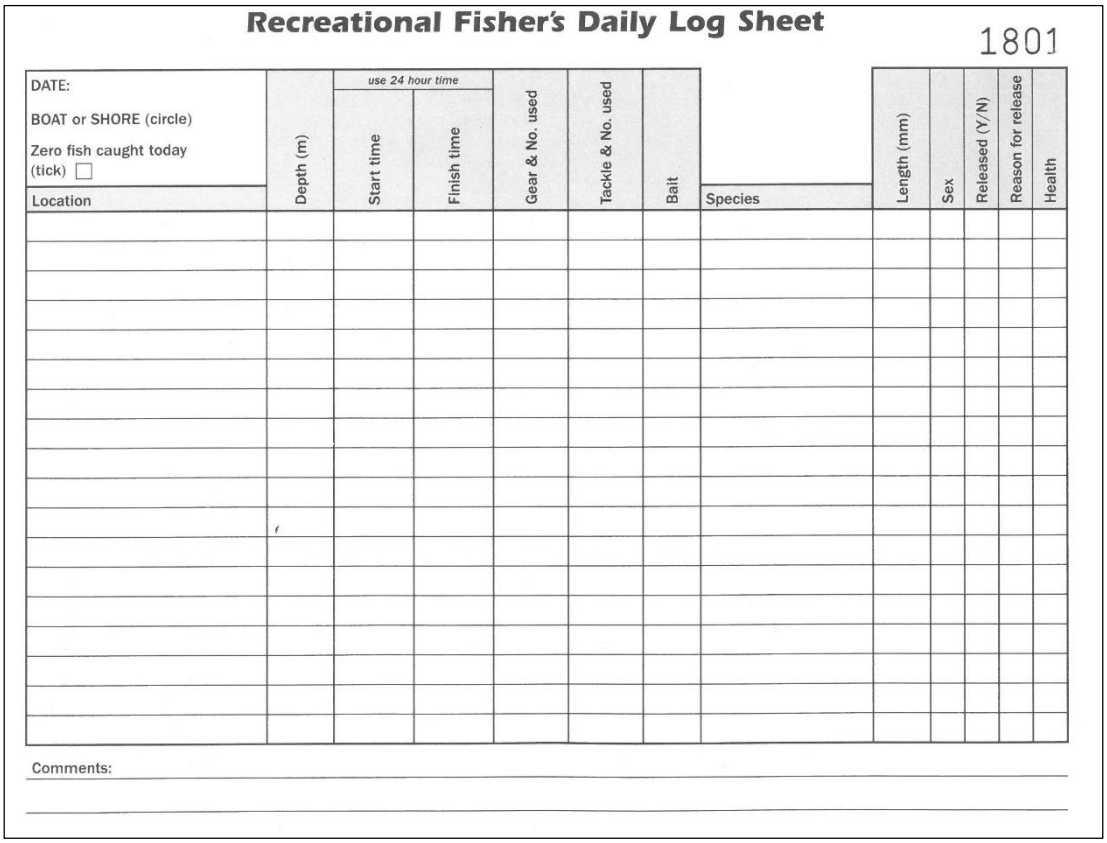
DAILY BYCATCH		TOTAL

PERSONAL NOTES:

Figure 8.1 Blue Swimmer Crab Daily Research log sheet completed by crab trap fishers in the Mandurah to Bunbury Developing Crab Fishery

Recreational logbook

A recreational fisher logbook program (Figure 8.2) commenced in 2013 as part of an external project funded by the Recreational Fishing Initiatives Fund (RFIF) and has continued for the Swan-Canning Estuary (SCE), LE and GB, to provide estimates of recreational crabbing catch rates and size composition (Harris *et al*., 2017). Annual data is presented by fishing year (1st June to 31st May) to allow for reporting by season.



Recreational Fisher's Daily Log Sheet

1801

DATE:
BOAT or SHORE (circle)
Zero fish caught today (tick) ☐
Location

Depth (m)	use 24 hour time: Start time	use 24 hour time: Finish time	Gear & No. used	Tackle & No. used	Bait	Species	Length (mm)	Sex	Released (Y/N)	Reason for release	Health

Comments:

Figure 8.2 Voluntary research log sheet completed by recreational crab fishers in the Leschenault Estuary and Geographe Bay as part of the Recreational Angler Program (RAP).

8.2.4 Fishery-Independent Monitoring

Breeding stock surveys have been conducted since 2013 during the peak spawning months of October and November to sample sexually mature and berried female *P. armatus* at eight sites in both LE (Figure 8.3) and GB (Figure 8.4) (Harris *et al*., 2017). Research hourglass traps are used (Figure 8.5), as they are most efficient at sampling larger crabs (Johnston *et al*., 2020b). Three baited traps (1.16 m diameter, 0.5 m high, constructed with 51 mm mesh and baited with approximately 220 g of yellow eye mullet) are deployed 100 m apart at each site for a 24-hour period, and carapace width (CW; to the nearest mm), sex, moult stage, and berried state recorded. Breeding stock and egg production indices have been developed and calculations and analyses are outlined in Section 9.3.6.

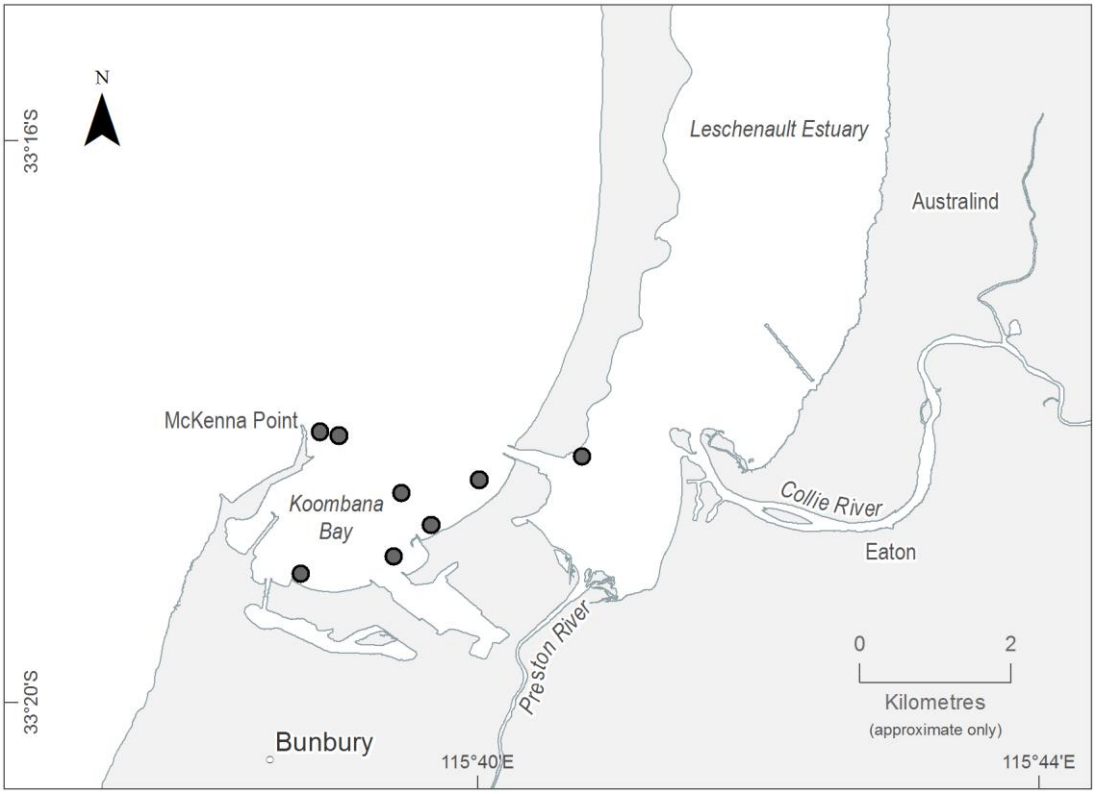


Figure 8.3 Breeding stock survey sites (circles) in the Leschenault Estuary and wider Bunbury area.

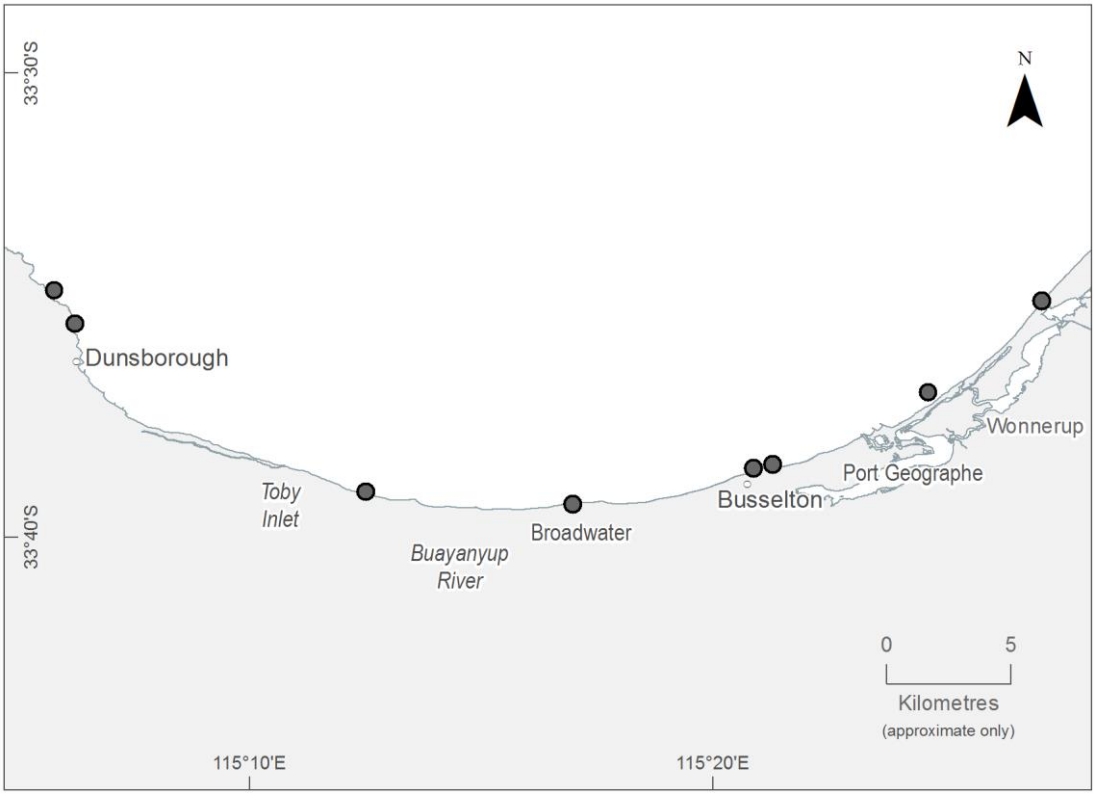


Figure 8.4 Breeding stock survey sites (circles) in Geographe Bay.

Figure 8.5 Hourglass research trap used in breeding stock surveys in the Leschenault Estuary and Geographe Bay.

8.2.5 Environmental Monitoring

Environmental databases are continuously updated and extended as new data becomes available from Departmental fishery dependent and fishery independent surveys (*e.g. in situ* temperature loggers and hand-held multi-parameter water quality meters) and other agency sources such as the Bureau of Meteorology, Department of Water and Environmental Regulation, Department of Biodiversity and Conservation and Cockburn Sound Management Council (*e.g.* rainfall, salinity, chlorophyll-a). The environmental variables from these databases have been used in reporting long-term environmental and fishery trends (*e.g.* 2010/11 marine heatwave), analyses of correlations with biological parameters of species, influences on commercial catch rates and stock-recruit-environment relationships (see Caputi *et al*., 2015; CSMC, 2018; Johnston *et al*., 2020a; Pearce *et al*., 2011).

8.2.6 Other Information

Length-Weight Relationships

Length (CW) and weight data were collected for a wide size range of crabs between 2014 and 2019 at six south-west fishery locations during fishery-dependent and fishery-independent surveys (Johnston and Yeoh, 2020). Locations included Comet Bay (CB), Geographe Bay, Cockburn Sound, Warnbro Sound, Peel-Harvey Estuary (PHE) and the SCE. Analyses results are summarised in Table 5.1 within Section 5.3.5 of Johnston *et al*. (2020b).

Reproduction – Size at Maturity and Fecundity

The reproductive biology of female *P. armatus* has been analysed, specifically size at maturity and batch fecundity, across a range of estuarine and coastal systems in WA (Johnston *et al*., in prep). Maturity data were collected between 2011 and 2019 from Shark Bay, Cockburn Sound,

Swan Canning Estuary, PHE, Geographe Bay, Koombana Bay and Leschenault Estuary, while fecundity data were collected in Shark Bay, Cockburn Sound and PHE during the summer of 2013/14. Analyses results are summarised in Table 5.1 within Section 5.3.5 of Johnston *et al*. (2020b).

9. Stock Assessment

9.1 Assessment Principles

The different methods used by the Department to assess the status of aquatic resources in Western Australia (WA) have been categorised into five broad levels, ranging from relatively simple analysis of catch levels and standardised catch rates, through to the application of more sophisticated analyses and models that involve estimation of fishing mortality and biomass (Fletcher and Santoro, 2015). The level of assessment varies among resources and is determined based on the level of ecological risk, the biology and population dynamics of the relevant species, the characteristics of the fisheries exploiting the species, data availability and historical level of monitoring.

Irrespective of the types of assessment methodologies used, all stock assessments undertaken by the Department take a risk-based, weight of evidence approach (Fletcher, 2015). This requires specifically the consideration of each available line of evidence, both individually and collectively, to generate the most appropriate overall assessment conclusion. The lines of evidence include the outputs that are generated from each available quantitative method, plus any qualitative lines of evidence such as biological and fishery information that describe the inherent vulnerability of the species to fishing. For each species, all of the lines of evidence are then combined within the Department's ISO 31000 based risk assessment framework (see Fletcher, 2015; Appendix 2) to determine the most appropriate combinations of consequence and likelihood to determine the overall current risk status.

9.2 Assessment Overview

In the absence of a population model, the annual assessment of *P. armatus* is based primarily on an analysis of commercial catch rates assumed to represent an index of abundance and a proxy for spawning biomass (Level 2 assessment). Commercial catch data are standardised to account for the effects of year, month and vessel (when multiple fishers are operating) on catch rates. These annual standardised catch rates are compared to reference points specified in the harvest strategy (DoF, 2015; DPIRD, 2020; Johnston *et al*., 2015a). Annual egg production indices (Level 4 assessment) are also generated for the Leschenault Estuary (LE) and Geographe Bay (GB).

A weight-of-evidence approach is applied to all fisheries where fishery-dependent and fishery-independent data are considered with the results of a Productivity Susceptibility Analysis (PSA) to evaluate the inherent vulnerability of each species to fishing.

9.2.1 Peer Review of Assessment

Stock assessments of key target species are internally reviewed as part of the Department's process for providing scientific advice to management and the Minister on the status of fish stocks. All commercial fisheries in WA underwent pre-assessment evaluation against the Marine Stewardship Council (MSC) standard for sustainable fishing in 2013-14 using a bioregional approach (Bellchambers *et al*., 2016).

9.3 Analyses and Assessments

9.3.1 Data Used in Assessment

CAES / Logbook
Economic data
Environmental data
Fishery-dependent data
Fishery-independent survey data

9.3.2 Catch and Effort Trends

9.3.2.1 Commercial Catch and Effort

West Coast Bioregion Overview

Commercial fishing for the blue swimmer crab in the West Coast Bioregion (WCB) includes the major fisheries of Cockburn Sound (CS), Swan-Canning Estuary (SCE) and the Peel-Harvey Estuary (PHE), as well as minor fisheries in Warnbro Sound (WS), Area 1 (Comet Bay: CB) and Area 2 (Mandurah to Bunbury: MB) of the Mandurah to Bunbury Developing Crab Fishery (MBDCF), and the Hardy Inlet (HI). Total annual catches increased from 54-100 t during the late 1970s and early 1980s, to over 250 t in the late 1990s and early 2000s (Figure 9.1). The highest catches on record of 524, 443 and 425 t occurred in 1997, 2000 and 1998, respectively. While the majority of catch from the WCB prior to 1995 was taken by gill net, fishing with purpose-designed crab traps is now the primary method (Figure 9.2).The number of fishing vessels retaining blue swimmer crabs in the WCB was highest in the late 1980s, peaking at 81 vessels in 1986 (Figure 9.1). The fleet decreased substantially in the late 1990s and early 2000s, with less than 25 vessels landing blue swimmer crabs annually since 2005.

The majority of the high blue swimmer crab catch during the late 1990s/early 2000s came from CS. Annual catches from 1995 to 2000 ranged from 194-360 t, following conversion of the fishery from gill nets to traps. Since the initial decline of the Cockburn Sound Crab Managed Fishery (CSCMF) in 2006, the PHE has become the principal fishery contributing to total commercial catch in the WCB, with a peak in 2013/14 of 107 t (Figure 9.1).

The total commercial catch from the WCB in 2019 was 92 t landed by 14 vessels (Figure 9.2), which contributed 15% to the total state-wide commercial blue swimmer crab catch of 614 t. Note, this 2019 state-wide total does not include data for the Shark Bay Crab Fishery in November and December 2019 (estimated <30 t). Of the 2019 WCB total, 70.1 t was landed

from the PHE, 9.5 t from the SCE and 11.2 t was landed from other areas (Table 9.1; Figure 9.1). No catch was taken from CS in 2019, as the fishery has remained closed since 2014.

Substantial recreational blue swimmer catch also occurs in the WCB. Recreational catches estimated by four state-wide surveys of recreational fishing from boats during 2011/12, 2013/14, 2015/16 and 2017/18 (Ryan *et al*., 2019) are shown in Figure 9.3. Shore-based recreational catch is also substantial in estuarine fisheries such as the PHE and SCE (Malseed and Sumner, 2001; Smith, 2006) and recent data for this component of the catch is currently being collected for assessment.

The highest boat-based recreational catches from 2011/12 to 2017/18 were taken in the PHE, with annual totals ranging from 26 to 46 t (Figure 9.3). Recreational boat-based catches across this period were lower in the SCE (6–17 t) and CS (6–13 t). Since the closure of CS in 2014, recreational fishing has only occurred north of Woodman Point.

Detailed recent commercial catch and effort information for WS, CB, MB and HI are provided in Sections 9.3.2.1.1 to 9.3.2.1.3. Refer to Johnston *et al*. (2020a) for assessment of the CS, SCE and PHE crab fisheries.

Table 9.1. Annual Landings (t) of blue swimmer crabs reported by the minor commercial crab fisheries in the West Coast Bioregion during 2019, compared to the five-year mean and total catch for each fishery from 2014-18 (calendar year). Other areas: Cockburn Sound Crab Managed Fishery, Area 1 (Swan-Canning Estuary) and Area 2 (Peel-Harvey Estuary) of the West Coast Estuarine Managed Fishery, Greenhead (Open Access).

Fishery	2019	2014-2018	
		Mean (± SD)	Total
Warnbro Sound Crab Managed Fishery	6.0	6.9 (± 5.0)	35
Comet Bay (Area 1 of the MBDCF)	2.4	4.6 (± 1.4)	23
Mandurah to Bunbury (Area 2 of the MBDCF)	0	< 1 (± 0.7)	1.5
Hardy Inlet (Area 3 of the WCEMF)	0	< 1 (± 0.06)	< 1
Other areas^	83.6	89 (± 31)	445
West Coast Bioregion Total	92	101 (± 32)	505

^Cockburn Sound closed to fishing since April 2014.

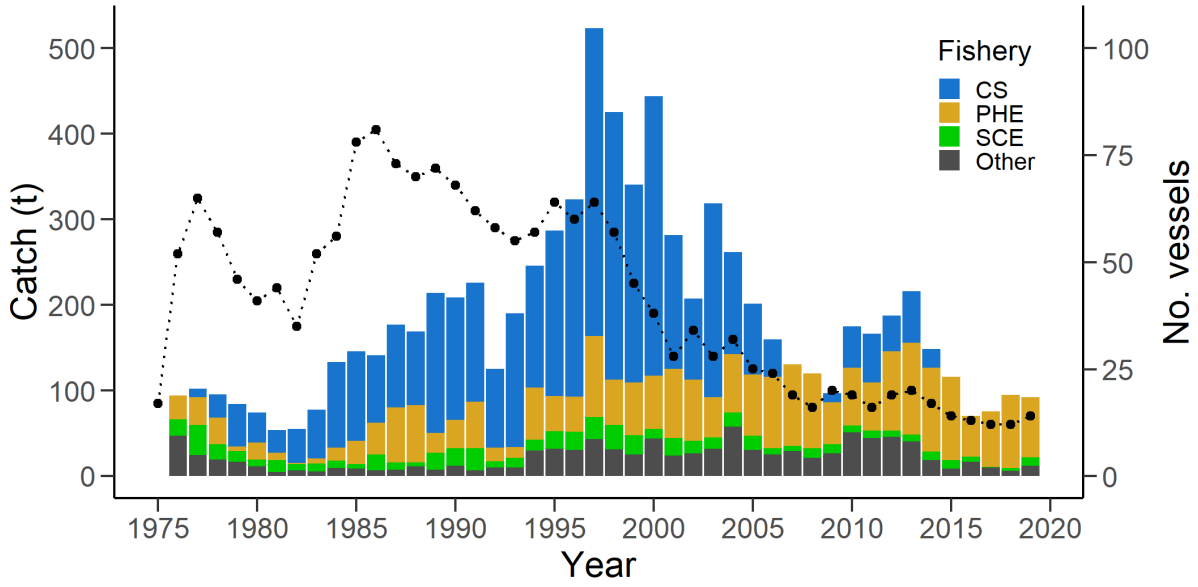


Figure 9.1. Annual commercial catch (by calendar year) for the blue swimmer crab fisheries in the West Coast Bioregion of Western Australia since 1976. The number of licensed fishing vessels retaining blue swimmer crabs each year is also shown (●). Other fisheries refer to any other commercial blue swimmer crab catch from the West Coast Bioregion, and includes Warnbro Sound, Mandurah to Bunbury Developing Crab Fishery (Area 1 and Area 2), Leschenault Estuary, Geographe Bay and Hardy Inlet.

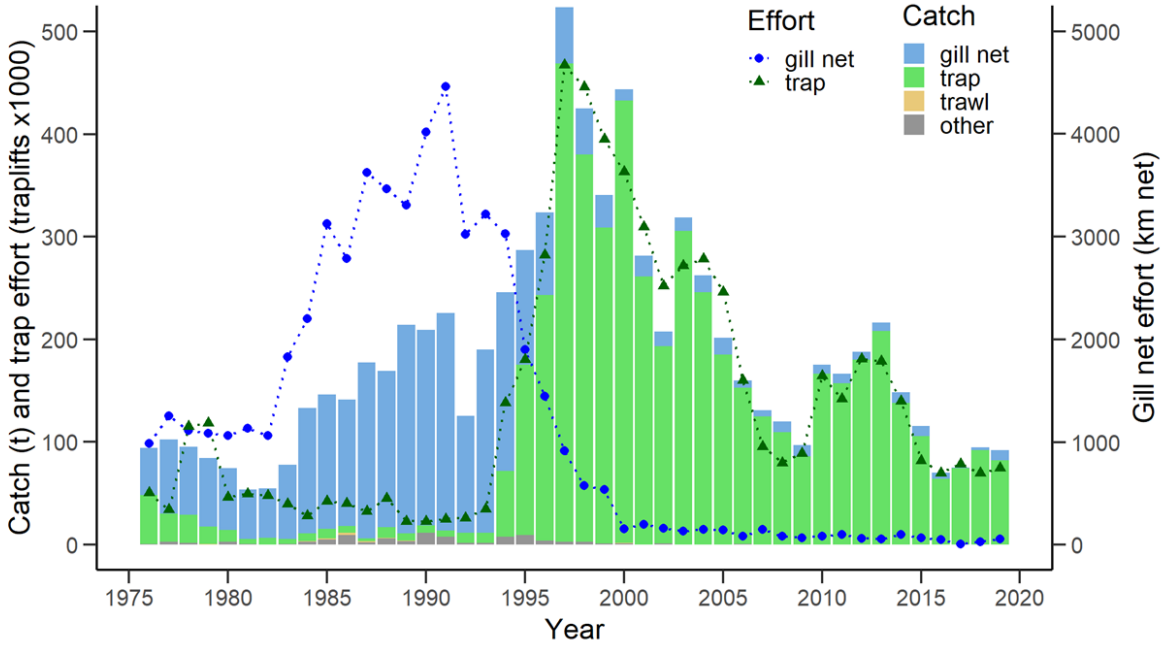


Figure 9.2. Total annual blue swimmer crab catch for the West Coast Bioregion caught by gill nets (set nets), traps, trawling and all other methods combined (e.g. haul net, beach seine) from 1976 to 2019. For clarity, effort is only shown for gill net and traps, which accounted for 99% of the total catch.

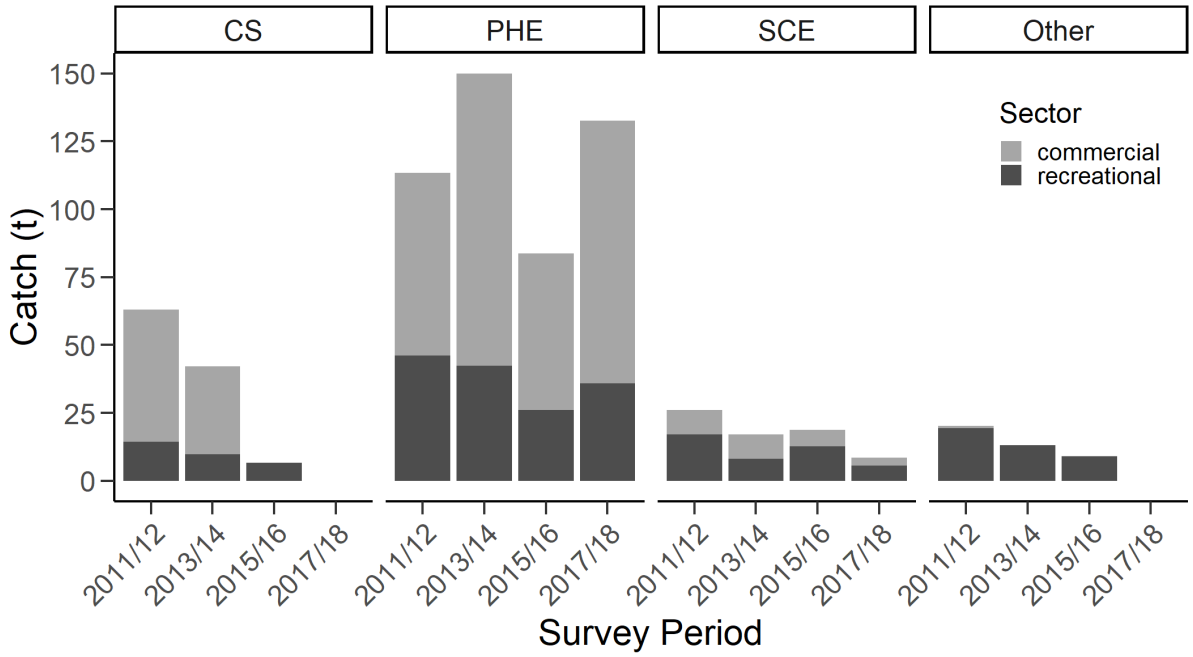


Figure 9.3. Total annual blue swimmer crab catch by recreational and commercial fishers in Cockburn Sound (CS), Peel-Harvey Estuary (PHE), Swan-Canning Estuary (PHE) and other key fishing areas (Geographe Bay and Hardy Inlet, combined) during three state-wide survey periods (i.e. March 2011 to February 2012; 2011-12, May 2013 to April 2014; 2013-14, September 2015 to August 2016; 2015-16, September 2017 to August 2018; 2017-18). Recreational catch was estimated using the boat-based fishing survey methodology outlined in Ryan et al. (2019) and extrapolated to also include shore-based fishing effort (Ryan et al., unpublished data). Note, 2017/18 data for CS and 'other' were not available at the time of publication. CS was closed to all commercial fishing from April 2014, and the allowable area for recreational fishing was reduced (see Section 6.2 for further details).

9.3.2.1.1 Warnbro Sound Crab Managed Fishery

While blue swimmer crabs in WS were targeted using gillnets during the first eight years of commercial fishing (1987-94), the single licensee has fished exclusively with purpose-designed crab traps since the implementation of the *Warnbro Sound (Crab) Fishery Management Plan* in 1995. There has been a change in licensee twice, in 2004/05 and 2014/15. A two-month closure over the peak spawning period for the WS crab stock (October-November) was also gazetted in the Management Plan, with a subsequent annual fishing season spanning 1st December to 30th September inclusive.

Although annual catch was relatively low during the gill net period of the Warnbro Sound Crab Managed Fishery (WSCMF; 2-4 t from ~2-61 km net length), catch fluctuated between 3-17 t (900-20,900 traplifts) between 1996/97 and 2008/09 following the conversion to purpose-designed crab traps (Figure 9.4). Catch and effort increased substantially over the next three years, to a peak of 35 t (26,700 traplifts) in 2011/12. This peak in catch coincided with a marine heatwave experienced on the West Australian coast between 2011-13 with water temperatures up to 4^{O} C higher than long term means. Although these high catch levels were maintained in the 2012/13 season (29 t from 23,400 traplifts), subsequent annual catches declined sharply to

less than 2 t from 5,280 traplifts in 2014/15 when a voluntary closure was implemented. Although fishing recommenced in 2015/16, with a total annual catch of 13 t from 15,690 traplifts, subsequent catches have remained low (~5 t from ~8,000 traplifts; Figure 9.4).

Total catch for the 2018/19 fishing season for the WSCMF was 5.3 t from 8,670 traplifts at a CPUE of 0.6 kg/traplift (Figure 9.4). Monthly catch (0.5-1.2 t), effort (720-2,200 traplifts) and CPUE (0.5-0.8 kg/traplift) were consistent across all months fished during the 2018/19 fishing season (Figure 9.5).

In contrast to most south west WA blue swimmer crab fisheries where catch and effort peaks over summer and autumn and declines in winter and spring, a more even spread across the months occurs in the WSCMF with a notable increase in catch in August and September (Figure 9.6). This is likely to be attributed to the increase in abundance of large crabs that are flushed out of the PHE during winter (lower salinities and water temperatures) and migrate through CB and into Warnbro Sound (Figure 9.6).

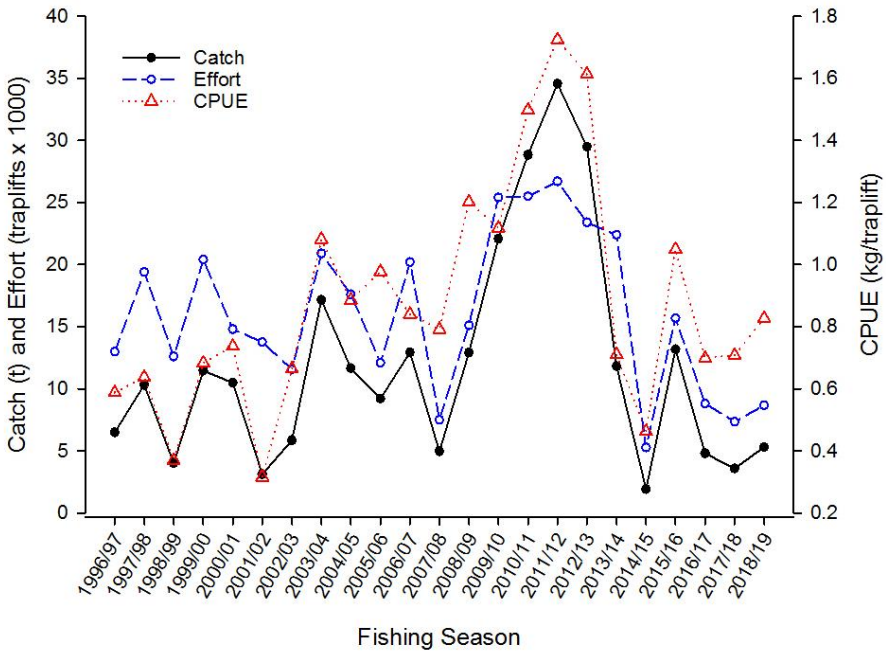


Figure 9.4 Historical commercial catch (t), effort (traplifts x 1000) and catch per unit effort (kg/traplift) by fishing season for the Warnbro Sound Crab Managed Fishery since converting exclusively to purpose-designed crab traps in 1996/97. The fishing season currently runs from 1 December to 30 September, with a spawning closure in October and November.

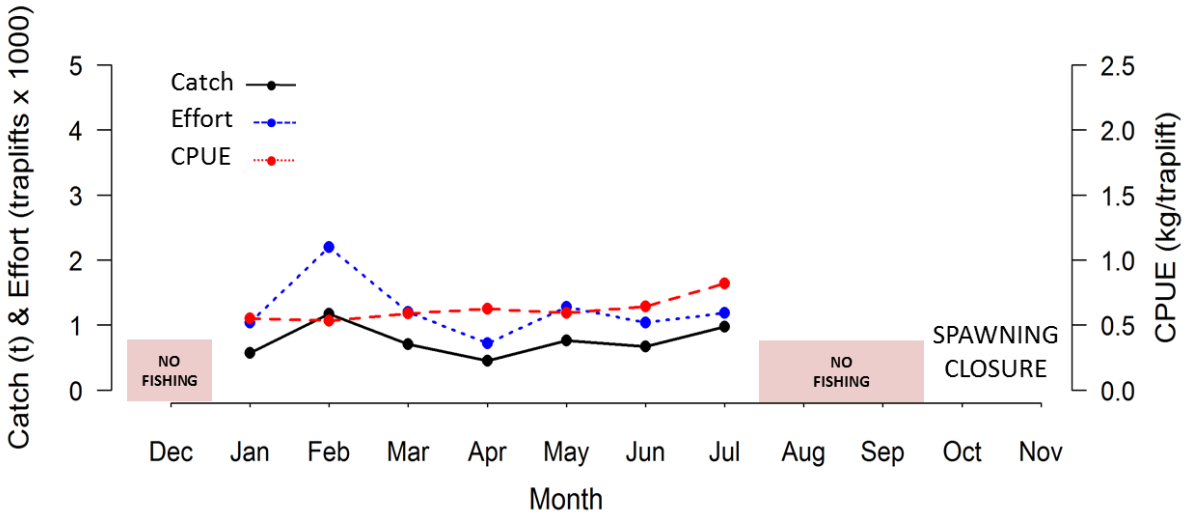


Figure 9.5 Commercial catch (t), effort (traplifts x 1000) and CPUE (kg/traplift) by month in the Warnbro Sound Crab Managed Fishery over the 2018/19 fishing season. The fishing season currently runs from 1 December to 30 September, with a spawning closure in October and November.

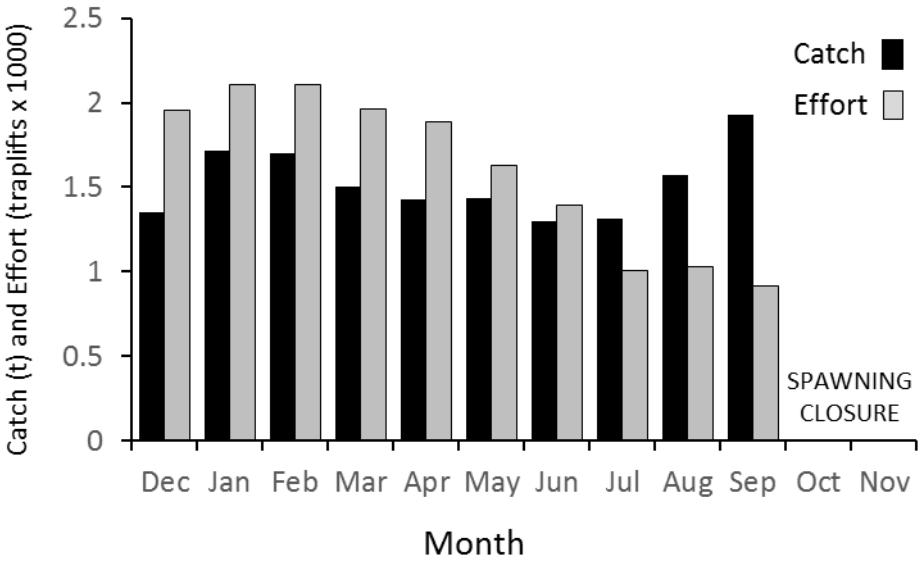


Figure 9.6 Mean monthly catch (t) and effort (traplifts x 1000) for the Warnbro Sound Crab Managed Fishery between 1996 and 2019. The fishing season runs from 1 December to 30 September, with a spawning closure in October and November.

9.3.2.1.2 Mandurah to Bunbury Developmental Crab Fishery

Catches of blue swimmer crabs in CB and MB have historically fluctuated with effort, with peaks in 2004 (23 t from 24,080 traplifts) and 2010 (30 t from 23,480 traplifts; Figure 9.7). Since 2013, catch has remained <10 t largely due to an absence of fishing in Area 2 since 2014 and the CB fisher spreading his effort with an endorsement to fish in the WSCMF (Figure 9.7). There is no seasonal closure in the MBDCF, and monthly catch (0.6-0.9 t) and effort (900-

1,400 traplifts) in CB has been relatively consistent (Figure 9.8). However, a peak in catch (1.6-1.9 t) and effort was evident over the autumn and spring periods in Area 2 (Figure 9.8).

The MBDCF reported total annual catch and effort for the 2019 calendar year of 2.4 t from 2,460 traplifts, representing 18% and 51% decreases in catch and effort respectively compared to 2018 (Figure 9.7) as fishing only occurred in four months of the year (Figure 9.9). Consequently, the catch rate increased from 0.6 kg/traplift in 2018 to 1.0 kg/traplift in 2019. This catch was exclusively from CB as no commercial fishing occurred in MB throughout the year.

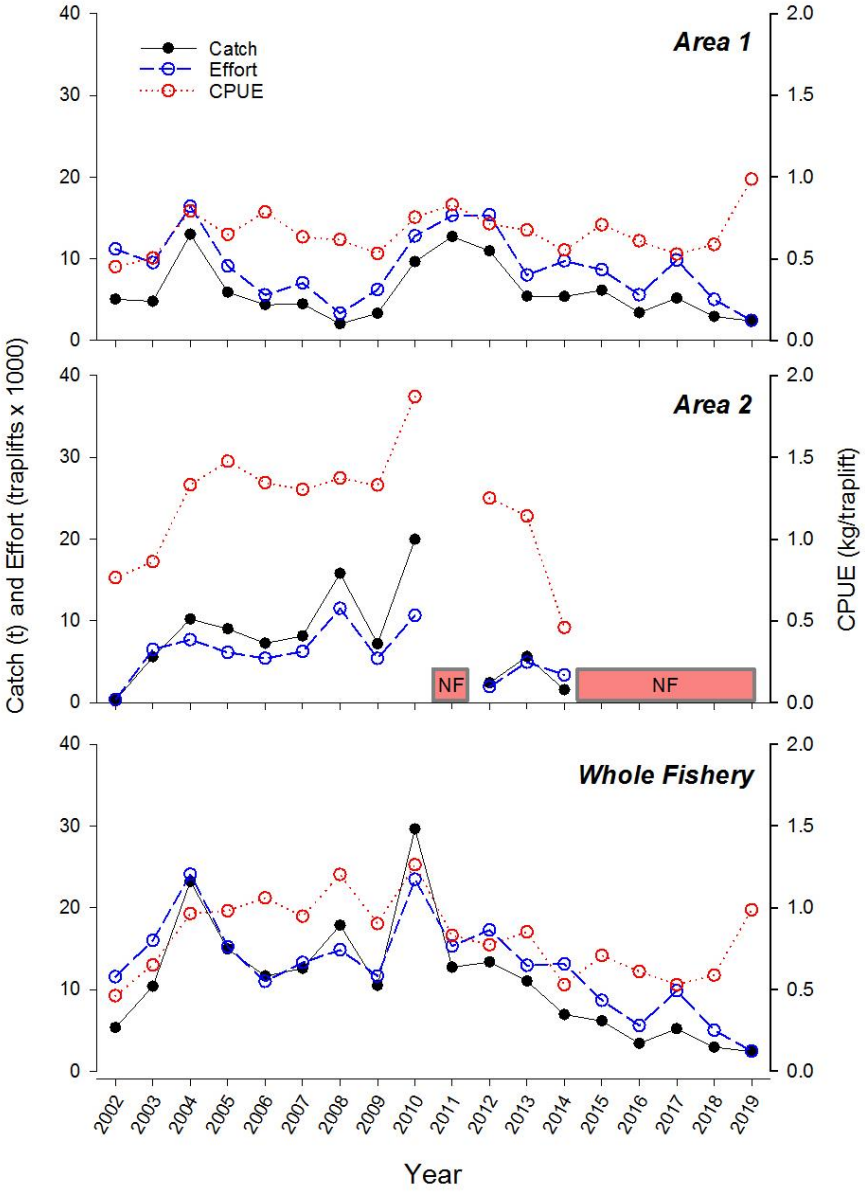


Figure 9.7 Annual commercial blue swimmer crab catch (t), effort (traplifts x 1000) and catch per unit effort (kg/traplift) for Area 1 (Comet Bay), Area 2 (Mandurah-Bunbury) and the whole Mandurah to Bunbury Developing Crab Fishery (total) by calendar year between 2002 and 2019. Area 2 has not been fished since 2014.

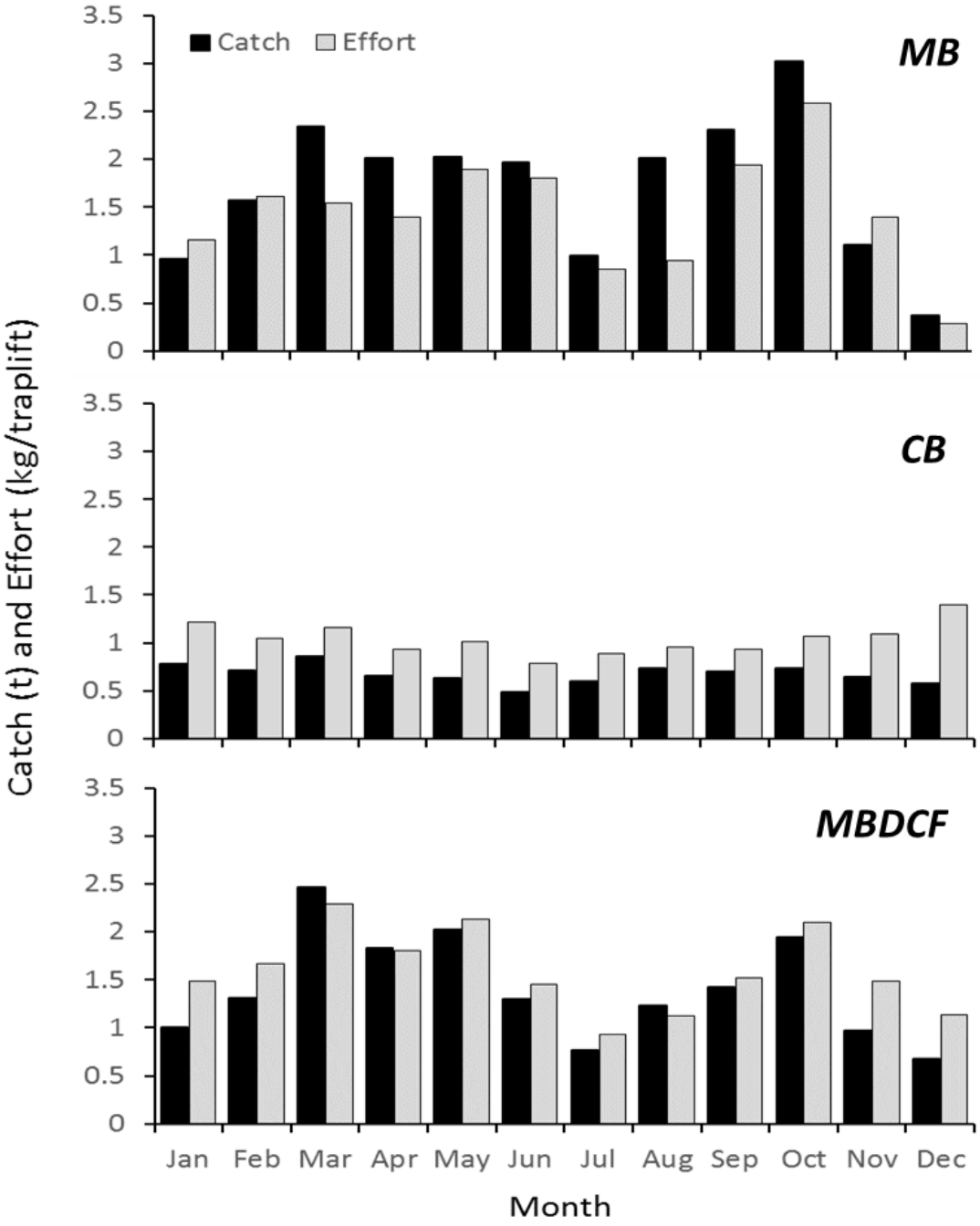


Figure 9.8 Mean monthly catch (t) and effort (traplifts x 1000) for Area 1 (Comet Bay), Area 2 (Mandurah-Bunbury) and the whole Mandurah to Bunbury Developing Crab Fishery between 2002 and 2019.

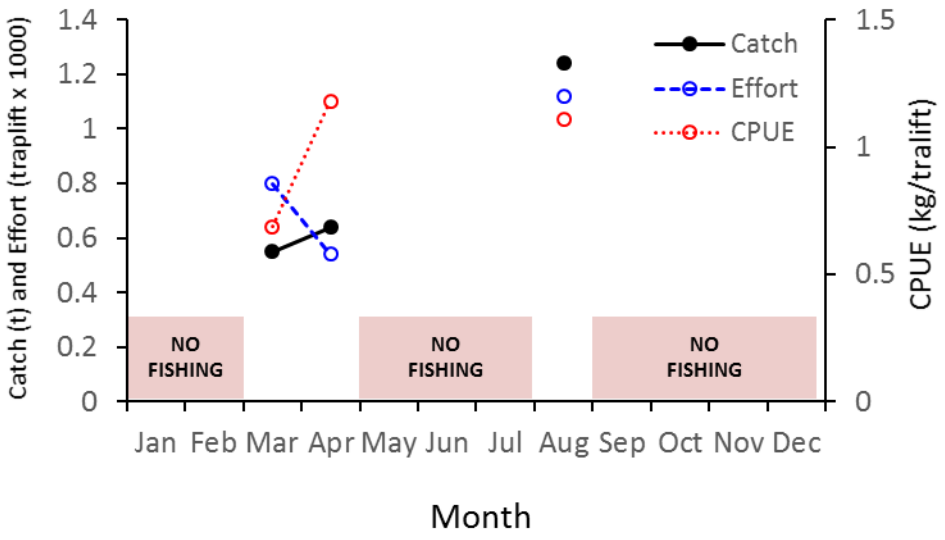


Figure 9.9 Commercial catch (t), effort (traplifts x 1000) and CPUE (kg/traplift) by month in Area 1 (Comet Bay) of the Mandurah to Bunbury Developing Crab Fishery during 2019. No fishing occurred in Area 2 (Mandurah to Bunbury) of the MBDCF during 2019.

9.3.2.1.3 Hardy Inlet (Area 3 of the West Coast Estuarine Managed Fishery)

Very low catches (< 1.5 t) of blue swimmer crabs have been reported from the HI since 2005, primarily in the summer/autumn period (November to April) as a by-product of the gill net fishery. Despite an exemption being issued in 2015 to trial purpose-designed crab traps, minimal commercial catch and effort resulted and there have been no landings of blue swimmer crabs reported for this fishery since 2016.

9.3.2.2 Recreational Catch and Effort

The majority of recreational blue swimmer crab catch (89%) in WA occurs in the WCB (Ryan *et al*., 2019). Recent recreational catch data for blue swimmer crabs has primarily been obtained from state-wide surveys of boat-based fishers during 2011/12, 2013/14, 2015/16 and 2017/18 ('iSurveys'; Ryan *et al*., 2013; 2015; 2017; 2019). Catches were recorded in numbers of crabs, and have been converted to a total harvest weight using an average weight estimated from on-site boat ramp surveys. The estimated boat-based recreational catch of blue swimmer crabs for the WCB during the 2017/18 survey period (September 2017 to August 2018) was 54 t (95% CI 45-63 t; Ryan *et al*., 2019). This was based on an estimated 249,112 crabs being kept at an average weight of 217 g. This is comparable with earlier estimates during 2015/16 and 2013/14 of 44 t and 59 t, respectively, but notably lower than during 2011/12 where 87 t was estimated to have been caught.

Historically, the blue swimmer crab resource of south-west WA has been fished by commercial and recreational sectors without any explicit catch share allocation between sectors. This is, in part, due to the limited data on recreational catches needed to understand changes in catch shares between these sectors over time (DPIRD, 2020). Early recreational surveys have not been comparable to the i-Survey estimates due to differences in survey methods.

Refer to Section 6.3 for a detailed description of the recreational sector.

9.3.2.3 Conclusion

Warnbro Sound Crab Managed Fishery	Recent catches in the WSCMF have remained low (~5 t; Figure 5.11), in part due to the current licensee spreading fishing effort between WS and Area 1 of the MBDCF. Total annual catch and effort for the 2018/19 season was 2.4 t from 2,460 traplifts, similar to the 3.6 t reported in 2017/18. Following recommendations from a management review of the south-west WA blue swimmer crab resource (DIPRD, 2018), the removal of commercial fishing effort from WS is due to be finalised in 2020 via a Voluntary Fishery Adjustment Scheme.
Mandurah-Bunbury Developing Crab Fishery	Annual commercial blue swimmer catch from the MBDCF has fluctuated (2-30 t) since its inception in 2002, with changes in catch largely reflecting effort. Following a peak of 29.6 t in 2010, annual catch has declined steadily, partly due to minimal fishing effort in Area 2, and a reduction in effort in Area 1 as the fisher spread effort with an endorsement to fish crabs in WS. Total annual catch and effort for 2019 was 2.4 t from 8,670 traplifts, similar to the 2.9 t reported in 2018. Following recommendations from a management review of the south-west WA blue swimmer crab resource (DPIRD, 2018), the removal of all commercial fishing effort from the MBDCF is due to be finalised in 2020 via a Voluntary Fishery Adjustment Scheme.
Area 3 of the West Coast Estuarine Managed Fishery (The Hardy Inlet)	Landings of blue swimmer crabs from the HI were first reported in 2005, with subsequent annual catches (<1.3 t) minimal compared to other WA fisheries. An exemption was issued in 2015 to trial traps to target blue swimmer crabs in HI. However, commercial trap catch and effort has been minimal with no reported catch since 2016.

9.3.3 Catch Distribution Trends

Commercial statutory catch data (CAES returns) are submitted on a block basis (60 x 60 nm) for all commercial fisheries. Given the relatively small spatial area over which blue swimmer crab fisheries operate in the WCB, these grids are not meaningful for spatial analysis. Therefore, GPS coordinates of fishing locations obtained during monthly commercial monitoring are used to provide fine-scale spatial resolution of monthly fishing activity. Additional fine-scale spatial information on commercial fishing is presented for Areas 1 and 2 of the MBDCF based on daily research logbook data. Spatial recreational data has been obtained through a Recreational Angler (logbook) Program (RAP) in the Leschenault Estuary and Geographe Bay.

9.3.3.1 Warnbro Sound Crab Managed Fishery

Commercial fishing effort for blue swimmer crabs in WS is focused on the deeper waters in the centre of the embayment (~15-20 m), and to a lesser extent the shallower fringing waters to the south (Figure 9.10). No distinct spatial or seasonal fishing pattern is apparent, with fishing effort evenly distributed across the embayment throughout the year. Male and female non-berried crabs were prevalent across all commercial monitoring trap lines sampled (Figure

9.11; Figure 9.12), whereas berried females were generally most abundant in the shallower fringing waters (Figure 9.13).

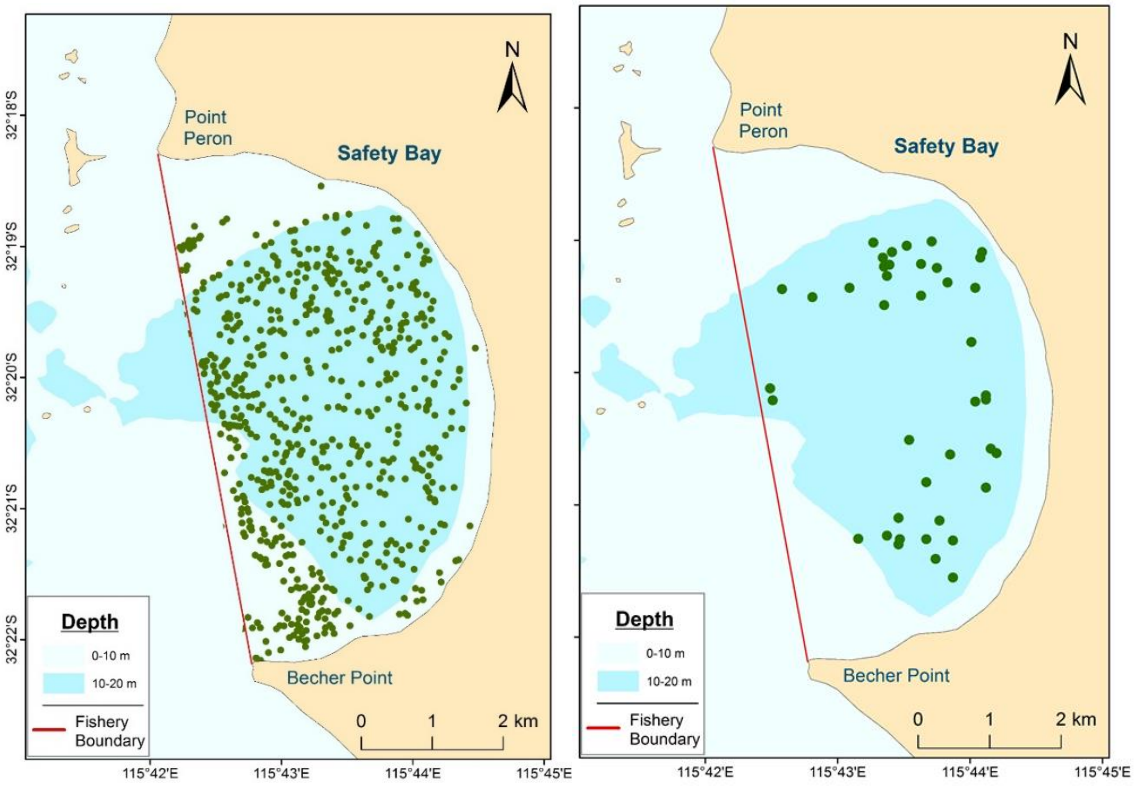


Figure 9.10 Start locations of trap lines sampled during commercial monitoring surveys in the Warnbro Sound Crab Managed Fishery between 2007/08-2018/19 (left), and during 2018/19 (right). Fishing season was from 1st December to 30th September inclusive.

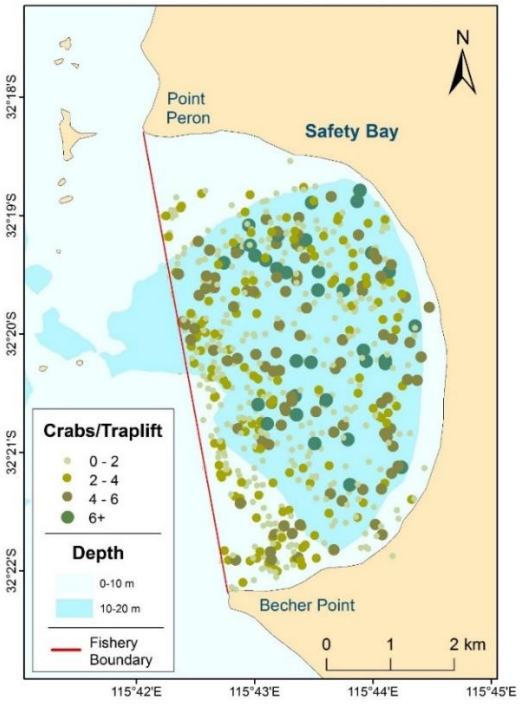


Figure 9.11 Catch rates of male blue swimmer crabs captured during commercial monitoring surveys within Warnbro Sound between 2007/08-2018/19 (left), and during 2018/19 (right). Fishing season is from 1st December to 30th September inclusive.

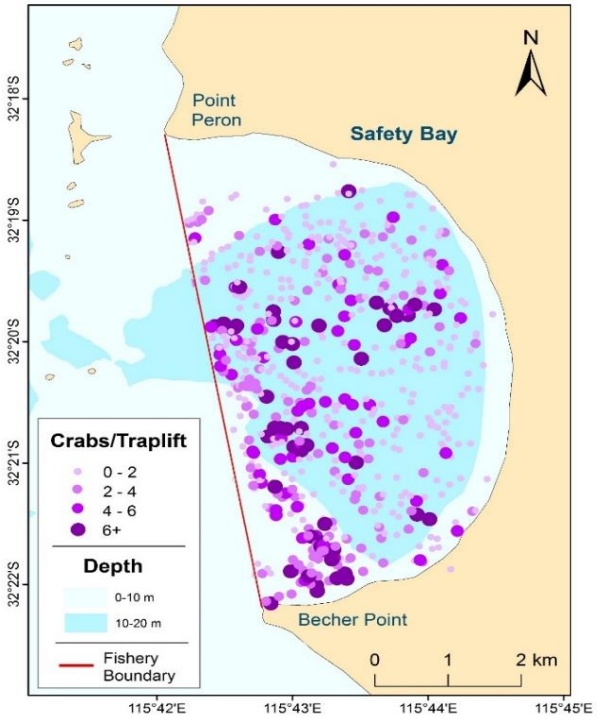


Figure 9.12 Catch rates of non-berried female blue swimmer crabs captured during commercial monitoring surveys within Warnbro Sound between 2007/08-2018/19. Fishing season was from 1st December to 30th September inclusive.

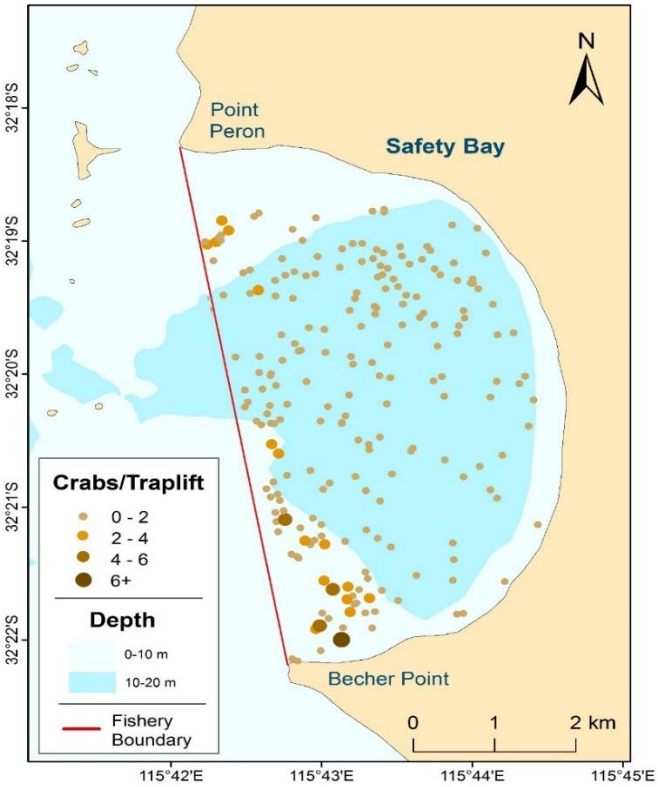


Figure 9.13 Catch rates of berried female blue swimmer crabs captured during commercial monitoring surveys within Warnbro Sound between 2007/08-2018/19. Fishing season was from 1st December to 30th September inclusive.

9.3.3.2 Mandurah to Bunbury Developing Crab Fishery

Area 1 (Comet Bay)

Prior to 2016, the trawl fishing boundary of Zone D of the South West Managed Trawl Fishery covered most of the seaward portion of CB, restricting the crab trap fisher to a narrow zone along the shore with deeper water to the south of the bay (Figure 9.14). Historically, fishing effort was spread throughout the coastal stretch of this nearshore zone each year. Following the closure of Zone D, the boundary of Area 1 of the MBDCF was modified to encompass some of the waters to the west of the trawl boundary while ceding some of the southern fishery. Exploratory trap fishing is now occurring in this region (Figure 9.14; Figure 9.15; Figure 9.16).

No distinct seasonal fishing pattern is apparent, with fishing effort evenly distributed along the CB shore throughout the year (Figure 9.14). Catch rates of male and female non-berried crabs were reasonably consistent across all commercially fished areas in CB (Figure 9.16; Figure 9.17), whereas berried females were most abundant in more southern, nearshore waters (Figure 9.18).

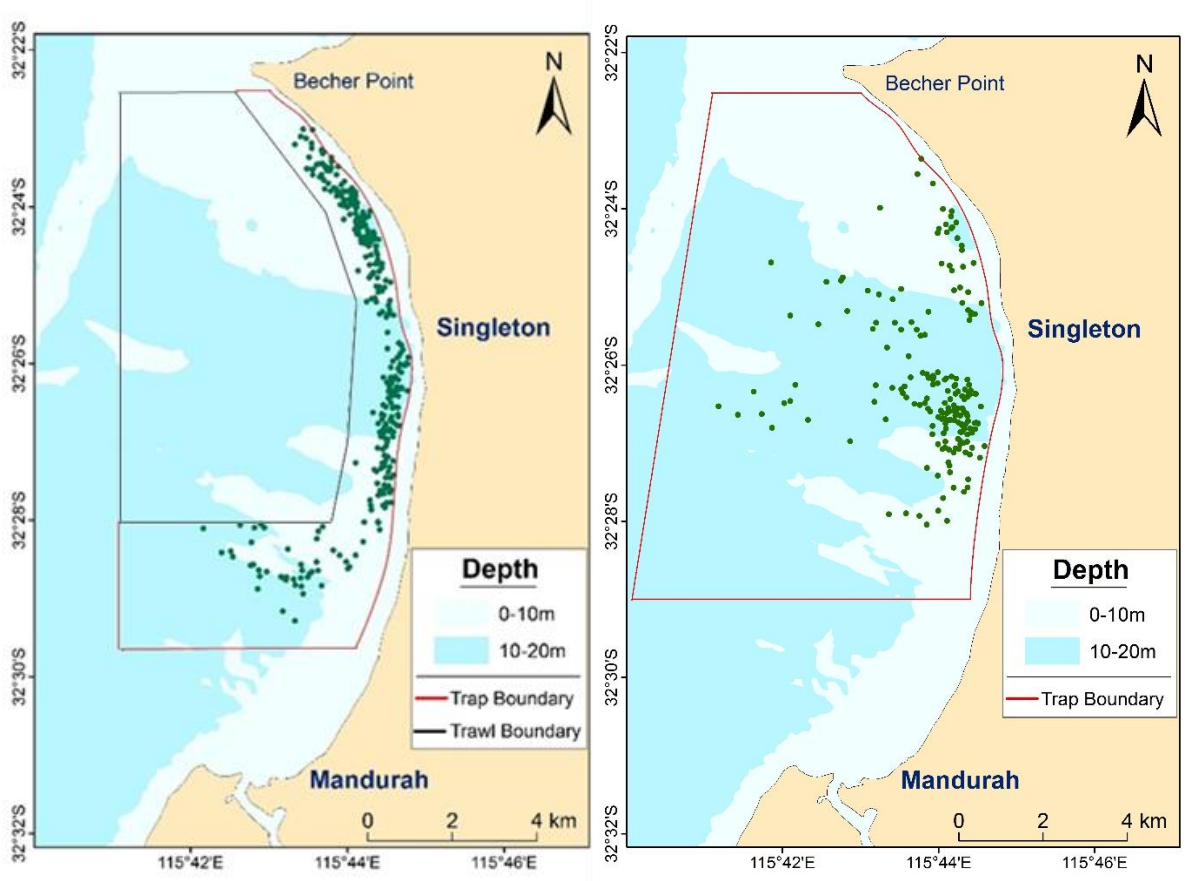


Figure 9.14 Start locations of trap lines sampled during commercial monitoring surveys in Comet Bay (Area 1 of the Mandurah to Bunbury Developing Crab Fishery) between 2007-15 (left) prior to the closure of Zone D of the South West Trawl Managed Fishery, and 2016-19 (right) following revision of the trap fishery boundary to include the previous trawl grounds.

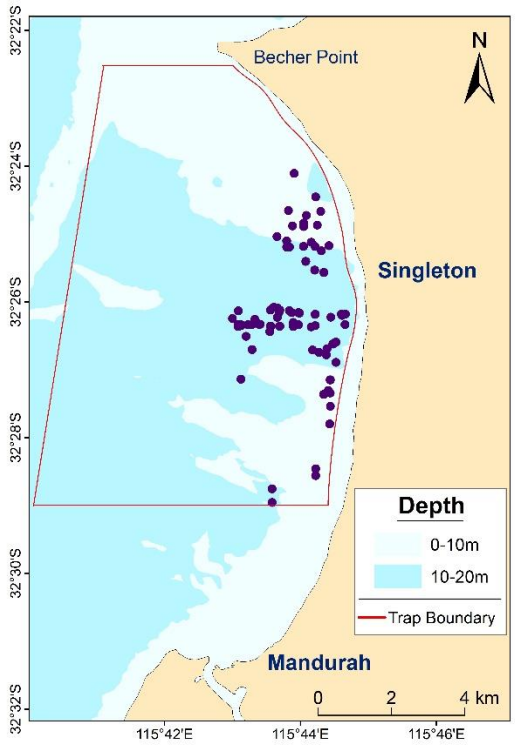


Figure 9.15 Start locations of trap lines in Comet Bay (Area 1 of the Mandurah to Bunbury Developing Crab Fishery) reported in Daily Research Logbooks between 2015-19.

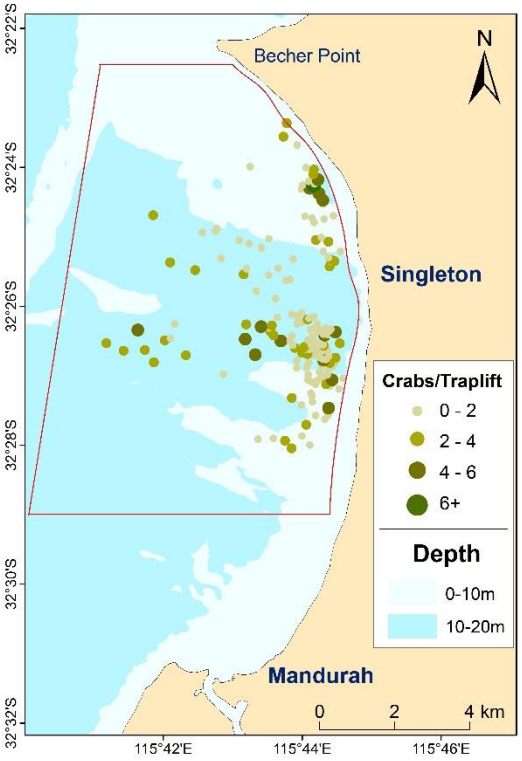


Figure 9.16 Catch rates of male blue swimmer crabs captured during commercial monitoring surveys in Comet Bay (Area 1 of the Mandurah to Bunbury Developing Crab Fishery) between 2007-19.

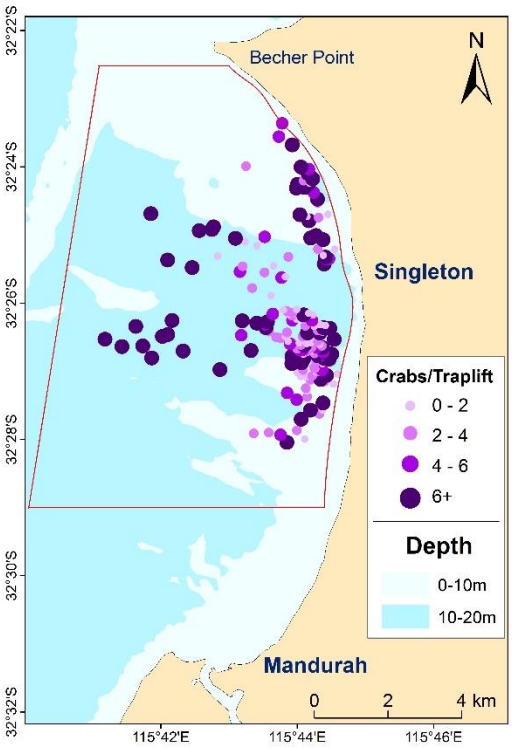


Figure 9.17 Catch rates of non-berried female blue swimmer crabs captured during commercial monitoring surveys in Comet Bay (Area 1 of the Mandurah to Bunbury Developing Crab Fishery) between 2007-19.

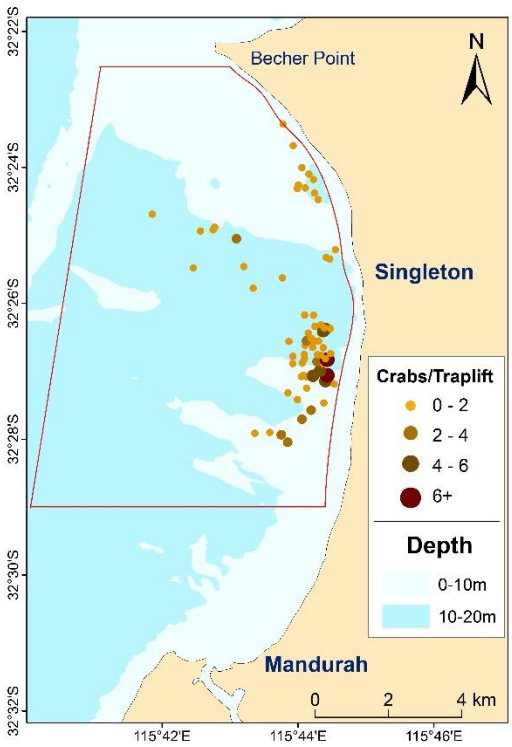


Figure 9.18 Catch rates of berried female blue swimmer crabs captured during commercial monitoring surveys in Comet Bay (Area 1 of the Mandurah to Bunbury Developing Crab Fishery) between 2007-19.

Area 2 (Mandurah to Bunbury)

Commercial trapping for blue swimmer crabs in Area 2 of the MBDCF is concentrated in nearshore waters (<1 km from shore) between White Hill and Binningup (Figure 9.19).

Catch rates of male and female non-berried crabs were reasonably consistent across all commercially fished areas in MB (Figure 9.20; Figure 9.21), whereas berried females were typically most abundant in more northern waters (Figure 9.22).

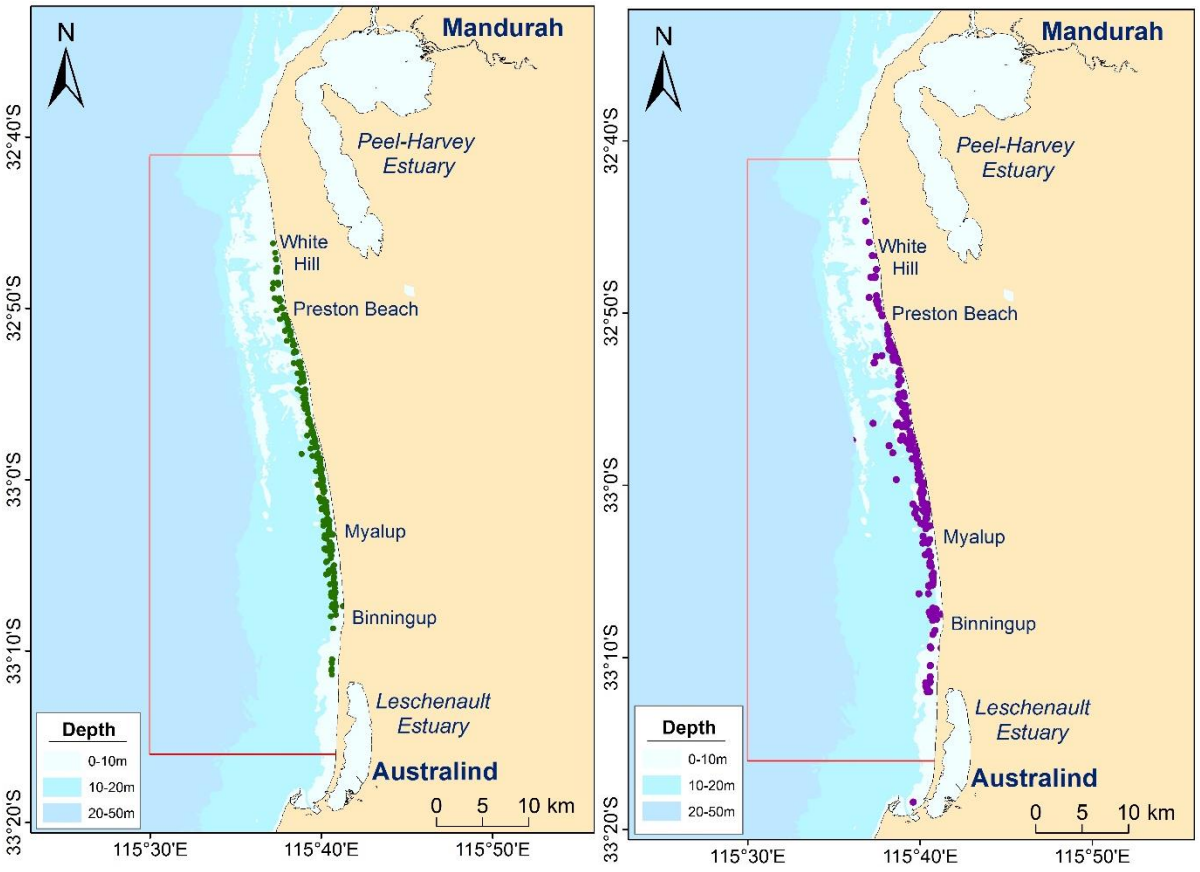


Figure 9.19 Start locations of trap lines sampled during monthly commercial monitoring surveys (left), and those reported for the fisher's daily crabbing activities in Daily Research Logbooks (right), in Mandurah to Bunbury (Area 2 of the Mandurah to Bunbury Developing Crab Fishery) between 2006-14. No commercial fishing has been undertaken in this fishery since 2014.

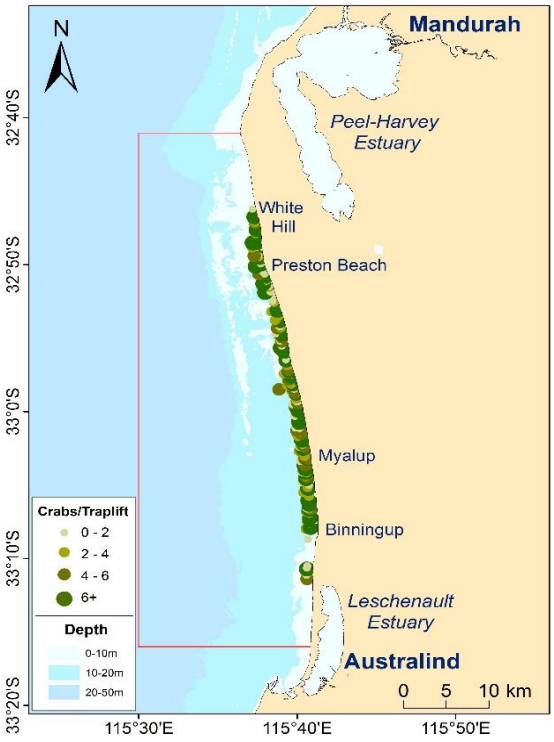


Figure 9.20 Catch rates of male blue swimmer crabs captured during commercial monitoring surveys between Mandurah and Bunbury (Area 2 of the Mandurah to Bunbury Developing Crab Fishery) from 2006-14.

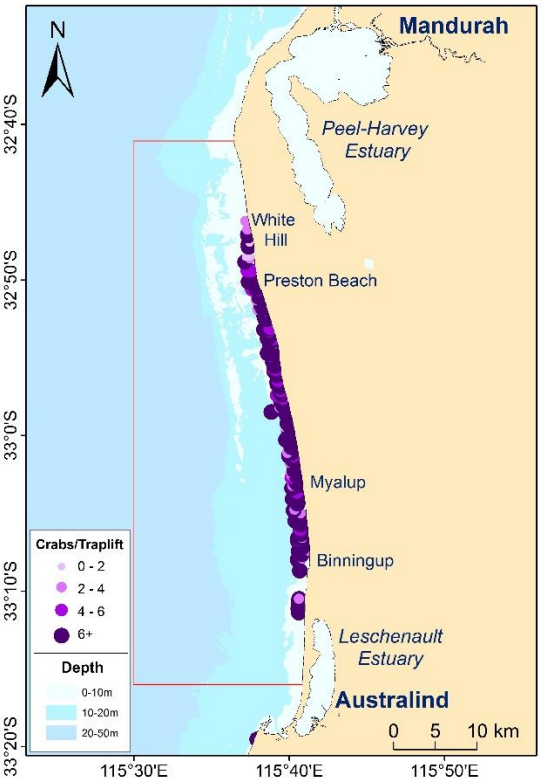


Figure 9.21 Catch rates of non-berried female blue swimmer crabs captured during commercial monitoring surveys between Mandurah and Bunbury (Area 2 of the Mandurah to Bunbury Developing Crab Fishery) from 2006-14.

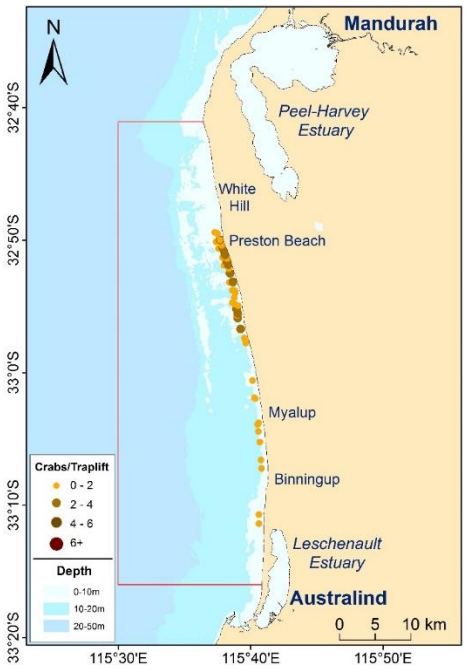


Figure 9.22 Catch rates of berried female blue swimmer crabs captured during commercial monitoring surveys between Mandurah and Bunbury (Area 2 of the Mandurah to Bunbury Developing Crab Fishery) from 2006-14.

9.3.3.3 Leschenault Estuary

Recreational crabbing effort reported in RAP logbooks between 2013-18 in the LE during winter focused on the sheltered oceanic waters of Bunbury Harbour, as lowering salinities from winter rains and declining water temperatures flushed crabs out of the estuary and into these nearshore marine waters (Figure 9.23). However, as salinity and temperature increased over spring, effort was more widely distributed in the Estuary and Collie River during the rest of the year (Figure 9.23).

Figure 9.23 Generalised crabbing locations by season reported in a voluntary logbook program by recreational fishers in the Leschenault Estuary and wider Bunbury area between June 2013 and May 2019 inclusive.

9.3.3.4 Geographe Bay

Boat-based recreational crabbing effort reported in RAP logbooks between 2013-18 in GB over winter occurred in a near-shore stretch of the bay from the Abbey Beach boat ramp in the west to just east of the mouth of the Wonnerup Estuary. Shore-based fishing was reported from the Busselton Jetty and within the Port Geographe marina (Figure 9.24). Effort over spring extended west to Dunsborough, before contracting to the region around, and within, the Port Geographe Marina during summer and autumn (Figure 9.24).

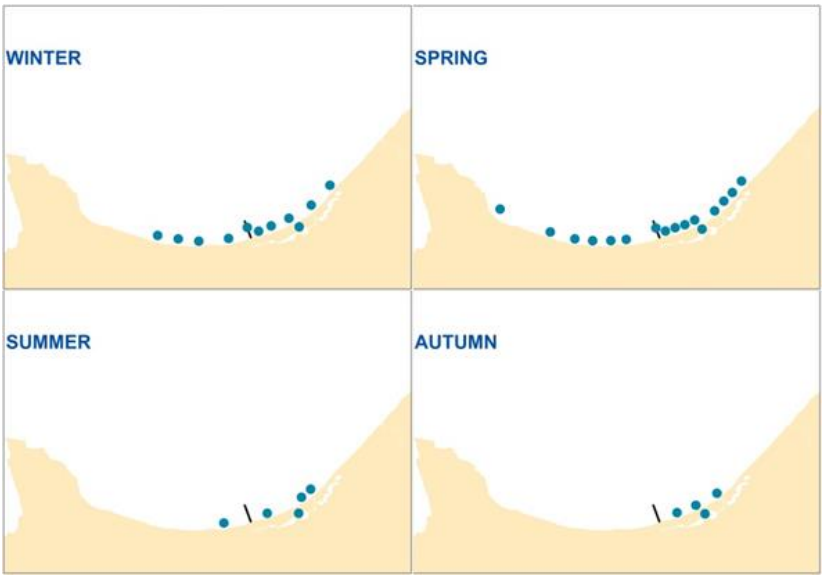


Figure 9.24 Generalised crabbing locations by season reported in a voluntary logbook program by recreational fishers in Geographe Bay between June 2013 and May 2019 inclusive.

9.3.3.5 Conclusion

Warnbro Sound Crab Managed Fishery	With little seasonal freshwater discharge into Warnbro Sound, the waters of the protected embayment remain marine. Consequently, commercial fishing occurs throughout the fishery with most effort focused in deeper waters in the centre of the embayment (~15-20 m) and the shallower fringing waters to the south. Male and female non-berried crabs were prevalent across all commercial monitoring trap lines sampled, whereas berried females were generally most abundant in the shallower waters fringing the central basin.

Mandurah-Bunbury Developmental Crab Fishery	Prior to 2016, trap fishing in CB was restricted to a narrow strip along the shore, but expanded into deeper waters following the closure of Zone D of the South West Trawl Managed Fishery. No distinct seasonal fishing pattern is apparent. Catch rates of male and female non-berried crabs were evenly distributed throughout fished areas, whereas berried females were most abundant in southern, nearshore waters of the embayment. Commercial trapping for blue swimmer crabs in MB is concentrated in nearshore waters (<1 km from shore) between White Hill and Binningup. Catch rates of male and female non-berried crabs were reasonably consistent across all commercially fished areas in MB, whereas berried females were typically most abundant in northern coastal waters of the fishery.
Leschenault Estuary	Recreational crabbing effort in the LE during winter focused on the sheltered oceanic waters of Bunbury Harbour, as lowering salinities and declining water temperatures flush crabs out of the estuary. With increasing salinity and temperature over spring, crabs return to the estuarine waters and effort was more widely distributed in the LE and Collie River during the remainder of the year.
Geographe Bay	Boat-based recreational crabbing effort over winter occurred in near-shore waters (< 200 m from shore) of GB (Abbey Beach boat ramp to the Wonnerup Estuary), with shore-based fishing from the Busselton Jetty and within the Port Geographe marina. Effort over spring extended west to Dunsborough, before contracting to the region around, and within, the Port Geographe Marina during summer and autumn.

9.3.4 Fishery-Dependent Catch Rate Analyses

A key component of stock assessment for the WSCMF, MBDCF and HI is commercial catch rate derived from monthly CAES returns. Trap effort is calculated as number of traplifts, with catch rates reported as landed catch weight (kg) per traplift. Effort for HI is presented in fisher day, due to the sporadic landings of blue swimmer crabs reported by multiple fishing methods. Recreational catch rates from the LE and GB are based on a voluntary logbook program, and calculated as numbers of crabs kept per 10 drop net pulls on each fishing occasion.

The annual catch rate for WS and MB has been standardised using a Generalised Linear Model (GLM) to account for the effects of year and month. The models were fit using a log-normal distribution, with CPUE as the response variable, with year and month as explanatory terms (which were considered categorical variables). Estimated marginal mean values for each year (i.e. annual standardised values) and associated confidence limits were then calculated. Due to minimal reporting of blue swimmer crab landings in the HI, nominal catch rates have been used to assess this fishery.

The catch rate in each fishery is assumed to represent an index of abundance for *P. armatus*, and is compared annually against reference levels as a primary performance indicator in harvest strategies for each fishery. However, annual catch rates may not necessarily be a reliable

indicator of stock abundance for HI, as crabs are generally retained as a by-product of the fisher's netting activity that targets finfish species.

9.3.4.1 Warnbro Sound Crab Managed Fishery

After several years of relative stability between 2004/05 and 2007/08, the annual standardised catch rate in the WSCMF increased from 0.8 kg/traplift in 2007/08 to a peak of 1.7 kg/traplift in 2011/12 (Figure 9.25). However, a sharp decline in catch rate from 1.6 kg/traplift in 2012/13 to 0.7 kg/traplift in 2013/14, fell below the threshold of 0.8 kg/traplift (Figure 9.25). A further decline in 2014/15 to 0.46 kg/traplift, which was below the limit of 0.55 kg/traplift (Figure 9.25), led to a review of the fishery and a voluntary closure was implemented for 7 months. Commercial fishing re-commenced in December 2015, with the annual standardised catch rate for 2015/16 of 1.0 kg/traplift back above the harvest strategy threshold. However, the catch rate again fell below the threshold in 2016/17 (0.7 kg/traplift) and 2017/18 (0.71 kg/traplift), before increasing above the threshold to 0.82 kg/traplift in 2018/19 (Figure 9.25).

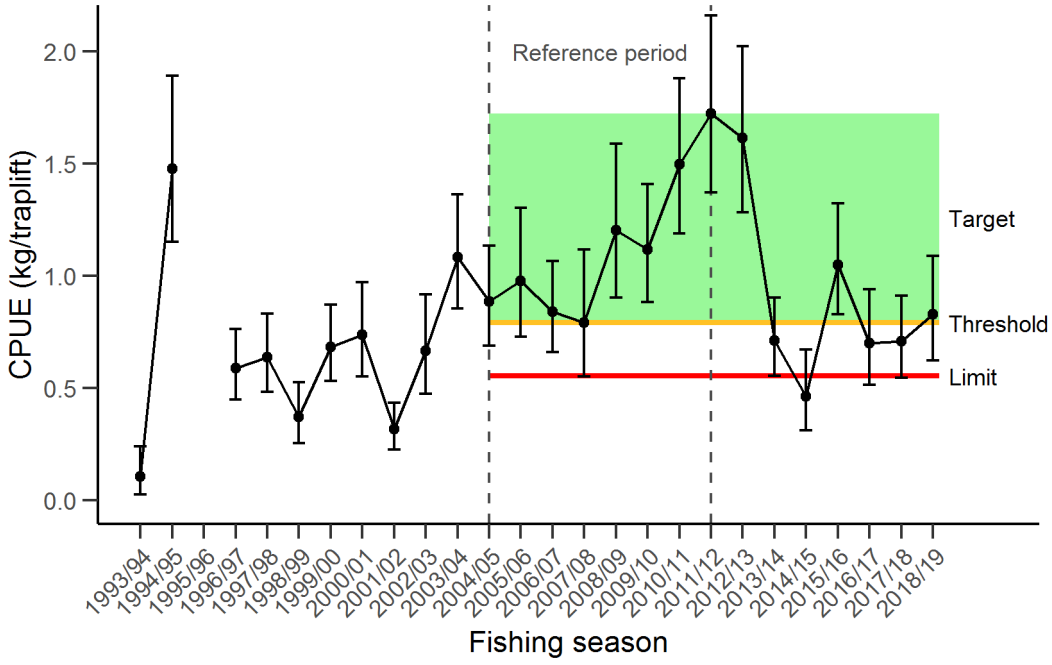


Figure 9.25 Primary performance indicator, annual standardised commercial catch rate (kg/traplift), of blue swimmer crabs by fishing season in the Warnbro Sound Crab Managed Fishery, with 95% confidence limits, relative to the associated reference points (target, threshold and limit) for the harvest strategy. The reference period (2004/05 to 2011/12) was a period of relative stability when the fishery was considered to have been operating sustainably. The target range extends between the maximum and minimum values of the reference period, where the latter denotes the threshold level, a proxy for the stock level at which Maximum Sustainable Yield (MSY) can be achieved. The limit is set at 70% of the threshold value (0.7BMSY). Fishing season is defined as 1 December to 31 September. Annual values have been standardised using a generalised linear model to account for effects of year and month.

9.3.4.2 Mandurah to Bunbury Developing Crab Fishery

Following a gradual increase in annual standardised catch rate for CB from 0.3 kg/traplift in 1998 to 0.8 kg/traplift in 2004, subsequent catch rates have been relatively stable (0.5-0.9 kg/traplift; Figure 9.26). The 2019 catch rate of 0.9 kg/traplift represents the highest annual standardised catch rate recorded for this fishery.

Following a sharp increase in annual standardised catch rate for MB from 2003 (0.8 kg/traplift) to 2004 (2.1 kg/traplift), catch rates over the next 7 years were relatively stable (1.6-2.2 kg/traplift; Figure 9.27). However, the catch rate declined to 1.6 kg/traplift in 2012 and 1.4 kg/traplift in 2013, which is below the threshold reference level (1.56 kg/traplift) for this fishery. There was a further sharp decline in 2014, with the annual standardised catch rate of 0.4 kg/traplift substantially below the limit reference level (1.09 kg/traplift). There has been no commercial fishing for blue swimmer crabs in MB since 2014.

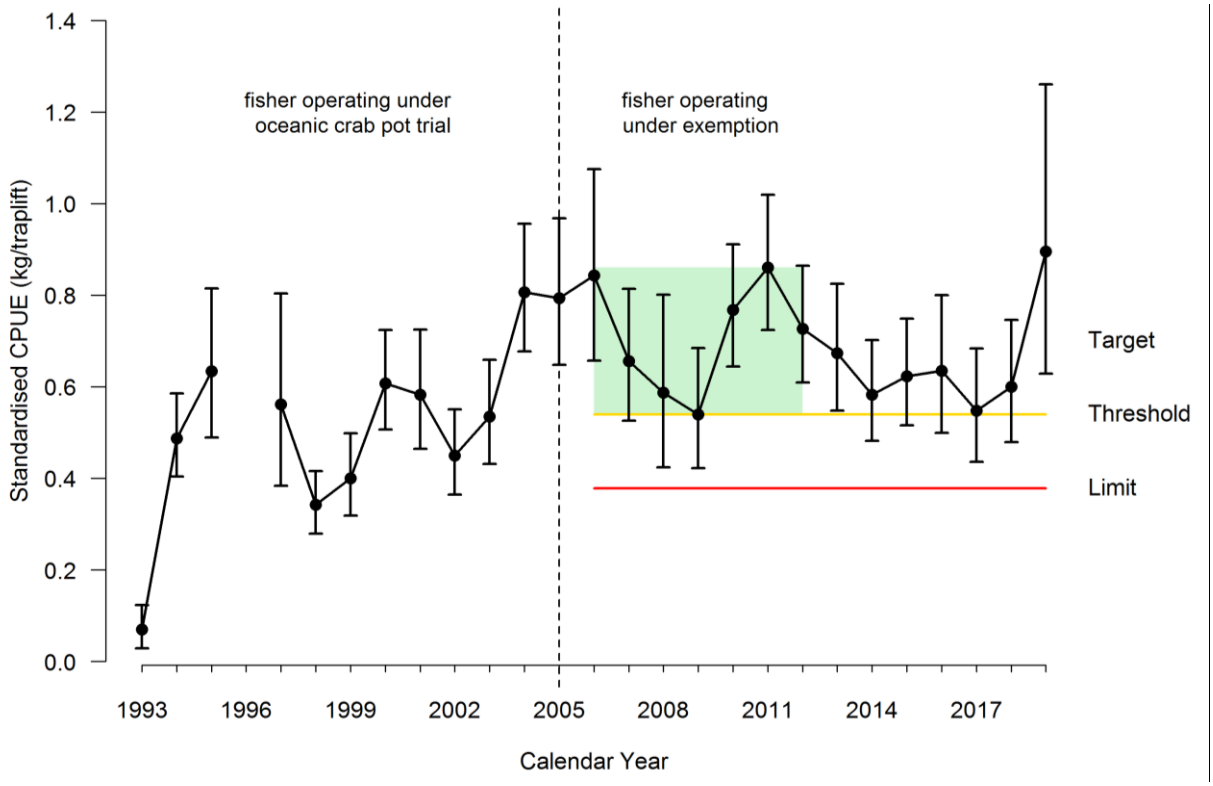


Figure 9.26 Primary performance indicator, annual standardised commercial catch rate (kg/traplift), of blue swimmer crabs by calendar year in Area 1 of the Mandurah to Bunbury Developing Crab Fishery (Comet Bay), with 95% confidence limits, relative to the associated reference points (target, threshold and limit) for the harvest strategy. The reference period (2006 to 2012) was a period of relative stability when the fishery was considered to have been operating sustainably. The target range extends between the maximum and minimum values of the reference period, where the latter denotes the threshold level, a proxy for the stock level at which Maximum Sustainable Yield (MSY) can be achieved. The limit is set at 70% of the threshold value (0.7BMSY). Annual values have been standardised using a generalised linear model to account for effects of year and month.

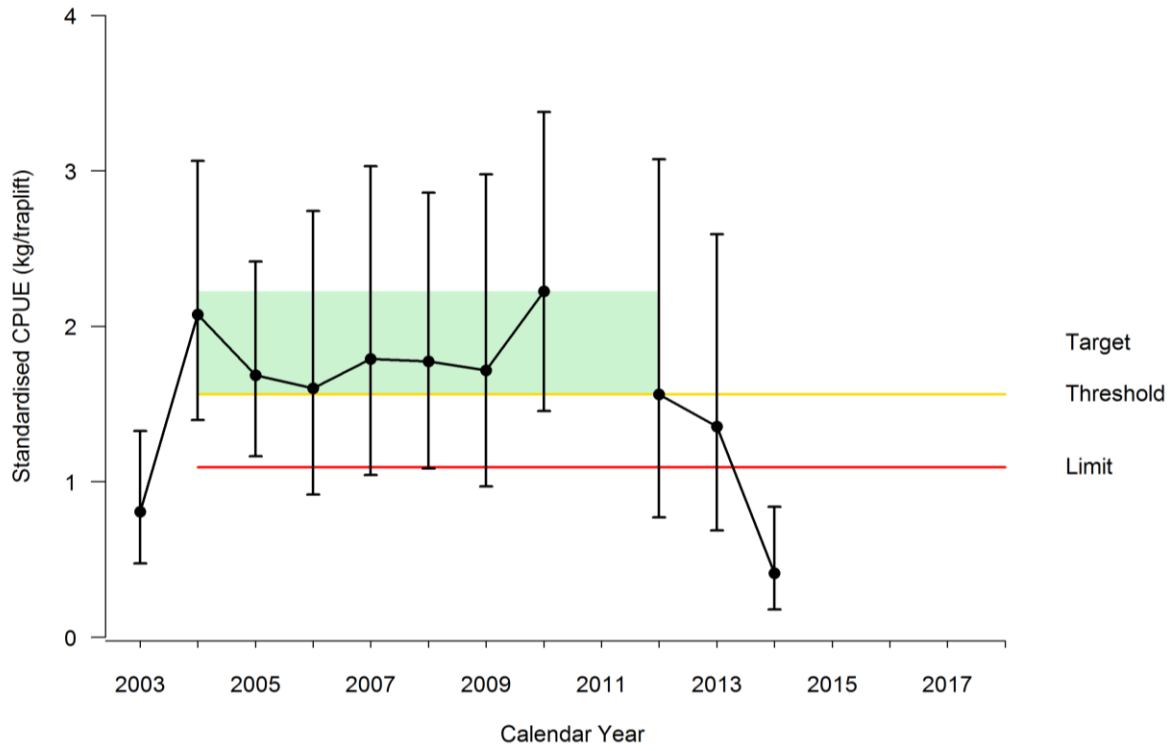


Figure 9.27 Primary performance indicator, annual standardised commercial catch rate (kg/traplift), of blue swimmer crabs by calendar year in Area 2 of the Mandurah to Bunbury Developing Crab Fishery (Mandurah to Bunbury), with 95% confidence limits, relative to the associated reference points (target, threshold and limit) for the harvest strategy. The reference period (2004 to 2012) was a period of relative stability when the fishery was considered to have been operating sustainably. The target range extends between the maximum and minimum values of the reference period, where the latter denotes the threshold level, a proxy for the stock level at which Maximum Sustainable Yield (MSY) can be achieved. The limit is set at 70% of the threshold value (0.7BMSY). Annual values have been standardised using a generalised linear model to account for effects of year and month.

9.3.4.3 The Leschenault Estuary

Recreational catch rates obtained through a voluntary recreational angler logbook program (RAP) have been variable between 2013/14 and 2017/18 in LE (Figure 9.28). However, catch rates in the past two fishing years have been relatively stable, with the 2017/18 catch rate of 4 retained crabs/10 drop net pulls the highest recorded over the five-year period (Figure 9.28).

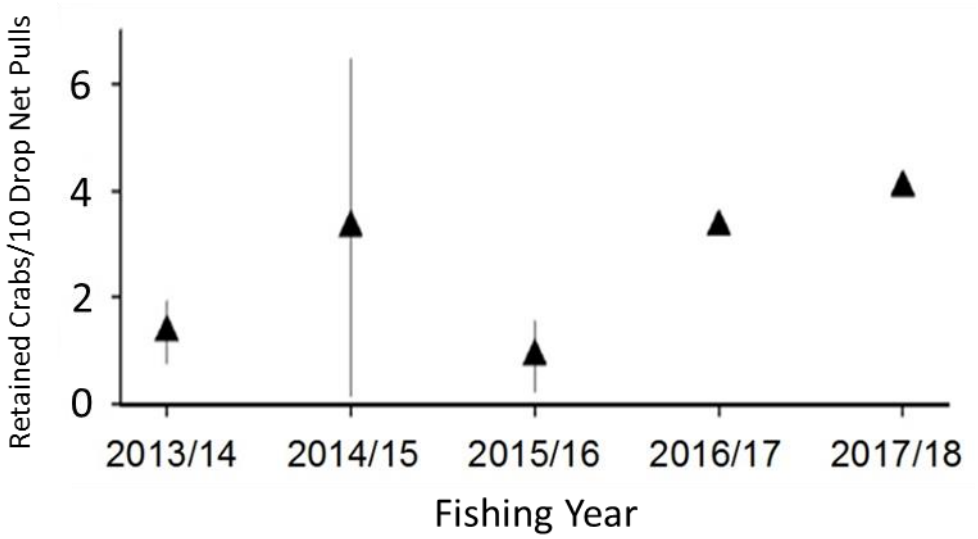


Figure 9.28 Annual recreational CPUE (number of retained crabs/ten drop net pulls) by fishing year for the Leschenault Estuary from 2013/14 to 2017/18 derived from a voluntary recreational angler logbook program. Fishing year refers to a 12-month period from June 1 to May 31 the following year. 95% CL presented.

9.3.4.4 Geographe Bay

Annual recreational catch rates obtained through a voluntary RAP in GB have been relatively consistent (1.8-2.3 retained crabs/10 drop net pulls) across the five-year period between 2013/14 and 2017/18 (Figure 9.29).

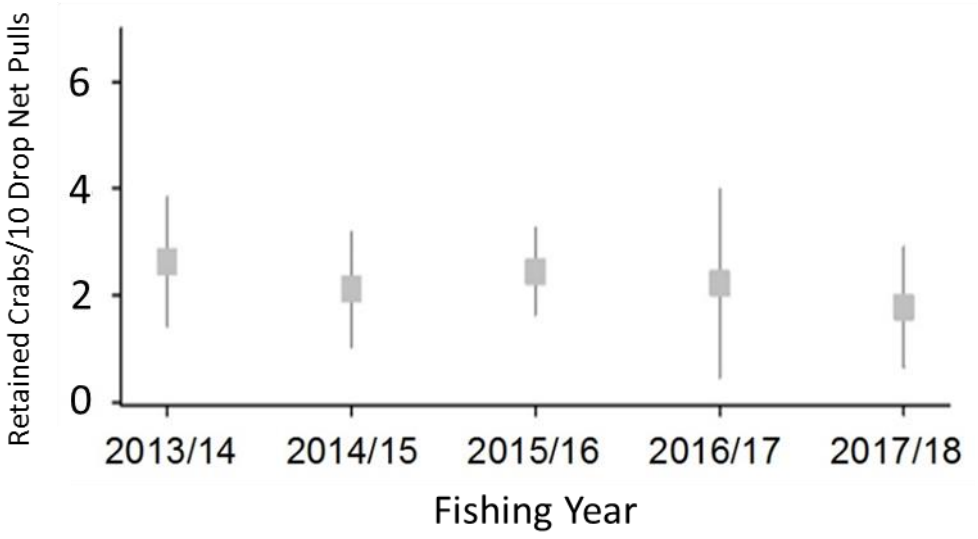


Figure 9.29 Annual recreational catch rate (number of retained crabs/ten drop net pulls) by fishing year for the Leschenault Estuary from 2013/14 to 2017/18 derived from a voluntary recreational angler logbook program. Fishing year refers to a 12-month period from June 1 to May 31 the following year. ±95% CL presented.

9.3.4.5 The Hardy Inlet

Nominal annual commercial blue swimmer crab catch rates for the HI are much lower than other WCB commercial fisheries, potentially due to crabs being retained as a by-product of the fisher's netting activity that targets finfish species. Therefore, annual catch rates may not be a reliable indicator of crab stock abundance for this fishery.

Catch rates ranged from 4-11 kg/day between 2005-08, with a substantial increase to 62 kg/fisher day in 2010 following a period of strong Leeuwin Currents and associated warmer water temperatures (Figure 9.30). However, it should be noted that blue swimmer crabs were reported on only three fisher days for this year. Catch rates returned to historical levels (~3 kg/fisher day) by 2013, with 9.6 kg/fisher day reported for 2016, after which no blue swimmer crab landings have been reported (Figure 9.30).

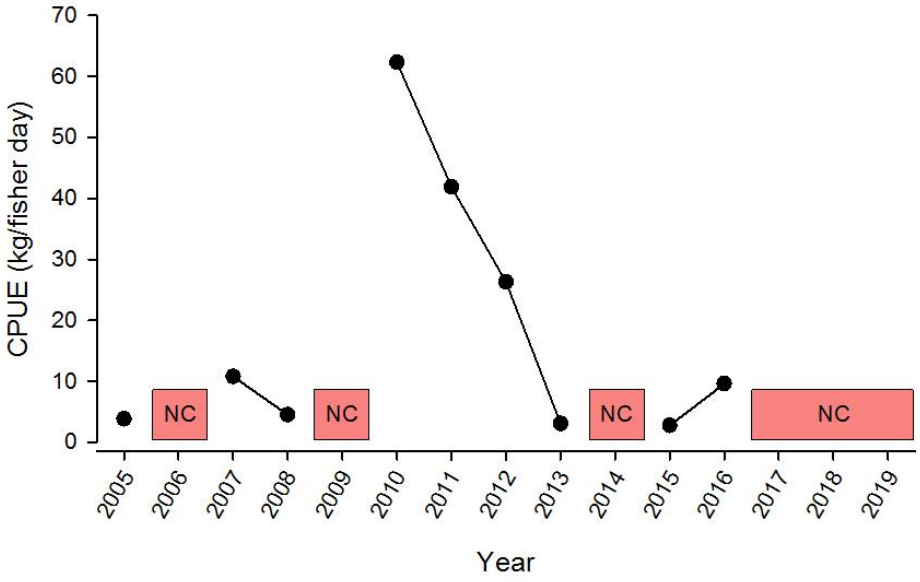


Figure 9.30 Nominal annual commercial blue swimmer crab catch rate (kg/fisher day) for all fishing methods (net and crab trap) in the Hardy Inlet (Area 3 of the West Coast Estuarine Managed Fishery) between 2005-2019. NC: Fishing occurred but no blue swimmer crab catch was reported.

9.3.4.6 Conclusion

Warnbro Sound Crab Managed Fishery	After several years of stability (0.8-1.0 kg/traplift) from 2004/05 to 2007/08, the annual standardised blue swimmer crab catch rate in the WSCMF increased to a peak of 1.7 kg/traplift in 2011/12. However, a subsequent decline in catch rate to below the harvest strategy limit triggered a review in 2014/15 that led to a voluntary closure for 7 months. Fishing recommenced for the 2015/16 season, with annual catch rate (1.0 kg/trap) above the harvest strategy threshold. However, the catch rate again fell below the threshold in 2016/17 and 2017/18, then increased to above the threshold (0.82 kg/traplift) in 2018/19.

Mandurah-Bunbury Developmental Crab Fishery	Following a gradual increase in annual standardised blue swimmer crab catch rate for CB from 0.3 kg/traplift in 1998 to 0.8 kg/traplift in 2004, catch rates have been relatively stable. The 2019 catch rate (0.9 kg/traplift) represents the highest annual standardised catch rate recorded since 1998. Following a sharp increase in annual standardised catch rate for MB from 2003 (0.8 kg/traplift) to 2004 (2.1 kg/traplift), catch rates over the next 7 years were relatively stable (1.6-2.2 kg/traplift). A decline in catch rate to just 0.4 kg/traplift occurred in 2014, which was substantially below the harvest strategy limit (1.1 kg/traplift). There has been no commercial fishing for blue swimmer crabs since 2014.
Leschenault Estuary	Recreational catch rates in LE varied considerably between 2013/14 and 2015/16 (Figure 9.33). However, catch rates in 2016/17 and 2017/18 have been relatively stable, with the 2017/18 catch rate of 4 retained crabs/10 drop net pulls being the highest recorded.
Geographe Bay	Annual recreational catch rates in GB have been relatively consistent (1.8-2.3 retained crabs/10 drop net pulls) between 2013/14 and 2017/18.
Area 3 of the West Coast Estuarine Managed Fishery (The Hardy Inlet)	Commercial blue swimmer crab catch rates for HI are much lower than other WCB commercial fisheries, possibly because crabs are generally not targeted, but rather retained as a by-product of the fisher's netting activity that targets finfish species. Nominal annual commercial catch rates of 4-11 kg/day were reported between 2005-08 and a substantial increase to 62 kg/fisher day was recorded in 2010. Catch rates returned to historical levels (~3-9 kg/fisher day) between 2013 and 2016. No landings of blue swimmer crabs have been reported in HI since 2016.

9.3.5 Fishery-Independent Data Analyses

9.3.5.1 Leschenault Estuary and Geographe Bay

Breeding stock surveys

Fishery-independent breeding stock surveys have been conducted during the peak spawning months of October and November in the LE and GB since 2013. From these surveys breeding stock potential is assessed through (a) catch rates of mature female crabs and (b) egg production. Sexual maturity was determined in the field, based on abdominal flap morphology (fused *vs* loose; see Section 5.3.5 of Johnston *et al*., 2020b for further details). Catch rates of sexually mature female crabs (number of crabs/traplift) were calculated by site, month and year. Egg production (number of eggs/traplift) was then calculated based on the catch rate of sexually mature females and a relationship between batch fecundity and crab size. Annual mean values and associated 95% confidence intervals for both metrics are presented.

Catch rates of sexually mature females in LE declined from 10.7 crabs/traplift in 2013 to 6.6 crabs/traplift in 2015, although this decline was not significant at the 95% confidence level (Figure 9.31). The catch rate then increased sharply in 2016 (13.0 crabs/traplift), before

declining to 6.0 crabs/traplift in 2017. Subsequent catch rates have increased since this point, to 11.5 crabs/traplift by 2019 (Figure 9.31). However, egg production in LE was comparatively consistent between years (14-22x10^6 eggs/traplift), other than in 2017 when egg production declined to 9.3x10^6 eggs/traplift (Figure 9.31).

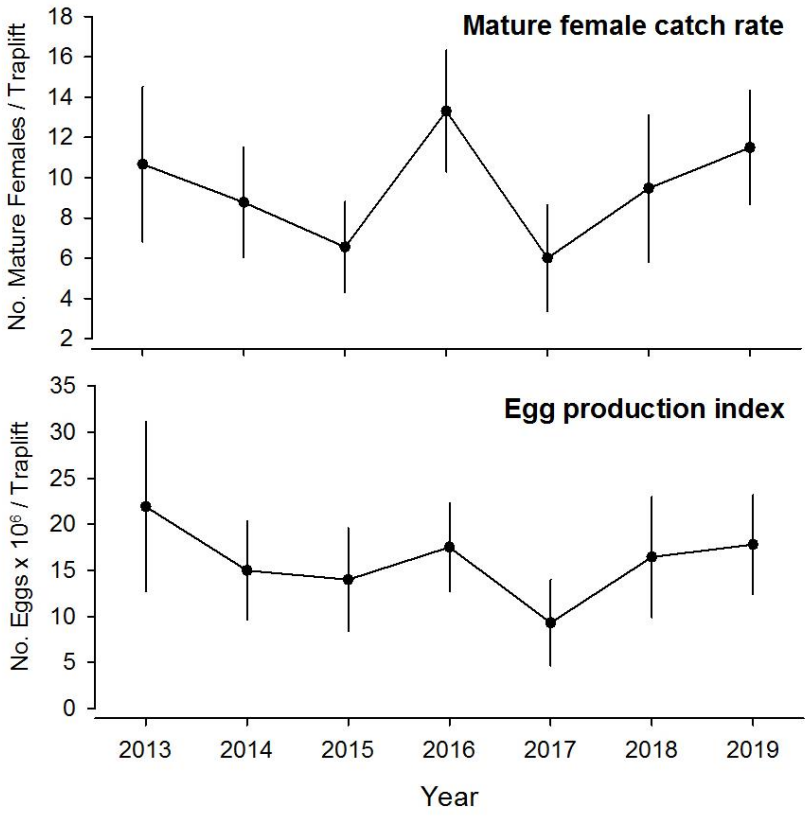


Figure 9.31 Mean annual catch rates (numbers of crabs / traplift; ± 95% confidence intervals) of sexually mature female blue swimmer crabs and associated egg production (numbers of eggs / traplift; ± 95% confidence intervals) recorded during breeding stock surveys (October & November) in the Leschenault Estuary between 2013 and 2019. Annual estimates have been calculated using a generalised linear model accounting for site and month. Sexual maturity was determined from abdominal flap morphology and egg production potential is based on a size-fecundity relationship which assumes all sexually mature females will contribute to egg production.

Annual catch rates of sexually mature females in GB declined from 13 to 6.6 crabs/traplift, before steadily returning to 13 crabs/traplift by 2017 (Figure 9.32). The catch rate was then steady (~8.8 crabs/traplift) in 2018 and 2019. Annual egg production in GB declined from 31×106 eggs/traplift in 2013 to 16×106 eggs/traplift in 2015, but was consistent (16-22×106 eggs/traplift) between 2016-19 (Figure 9.32).

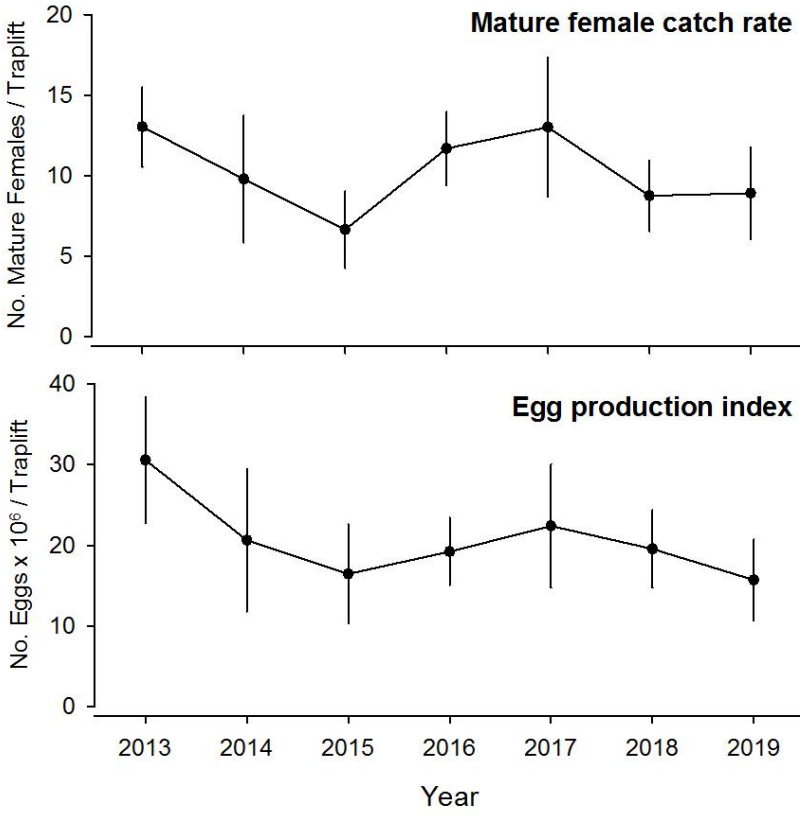


Figure 9.32 Mean annual catch rates (numbers of crabs / traplift; ± 95% confidence intervals) of sexually mature female blue swimmer crabs and associated egg production (numbers of eggs / traplift; ± 95% confidence intervals) recorded during breeding stock surveys (October & November) in Geographe Bay between 2013 and 2019. Annual estimates have been calculated using a generalised linear model accounting for site and month. Sexual maturity was determined from abdominal flap morphology and egg production potential is based on a size-fecundity relationship which assumes all sexually mature females will contribute to egg production.

9.3.5.2 Conclusion

Leschenault Estuary Breeding Stock Survey	Catch rates of sexually mature females in LE declined from 10.7 crabs/traplift in 2013 to 6.6 crabs/traplift in 2015, although this decline was not significant at the 95% confidence level. The catch rate then increased sharply in 2016 (13.0 crabs/traplift), before declining to 6.0 crabs/traplift in 2017. Subsequent catch rates have increased since this point, to 11.5 crabs/traplift by 2019. Egg production in LE was comparatively consistent between years (14-22x106 eggs/traplift), other than in 2017 when egg production declined to 9.3x106 eggs/traplift. The egg production index in LE will continue to be monitored. A longer time series is required for the status of breeding stock in these fisheries to be adequately assessed, when a threshold and limit for these indices will be developed.

Geographe Bay Breeding Stock Survey	Annual catch rates of sexually mature females in GB declined from 13 to 6.6 crabs/traplift, before steadily returning to 13 crabs/traplift by 2017. The catch rate was then steady (~8.8 crabs/traplift) in 2018 and 2019. Annual egg production in GB declined from 31×106 eggs/traplift in 2013 to 16×106 eggs/traplift in 2015, but was consistent (16-22×106 eggs/traplift) between 2016-19. The egg production index in GB will continue to be monitored. A longer time series is required for the status of breeding stock in these fisheries to be adequately assessed, when a threshold and limit for these indices will be developed.

9.3.6 Productivity Susceptibility Analysis

Productivity Susceptibility Analysis (PSA) is a semi-quantitative risk analysis originally developed for use in MSC assessments to score data-deficient stocks, i.e. where it is not possible to determine status relative to reference points from available information (Hobday *et al*., 2011; MSC, 2014). The PSA approach is based on the assumption that the risk to a stock depends on two characteristics: (1) the productivity of the species, which will determine the capacity of the stock to recover if the population is depleted, and (2) the extent of the impact on the stock due to fishing, which will be determined by the susceptibility of the species to fishing activities (see Appendix 3).

Although a valuable tool for determining the overall inherent vulnerability of a stock to fishing, the PSA is limited in its usefulness for providing stock status advice. This is because of the simplicity and prescriptiveness of the approach, which means that risk scores are very sensitive to input data and there is no ability to consider management measures implemented in fisheries to reduce the risk to a stock (Bellchambers *et al*., 2016). Consequently, the PSA is used by the Department to produce a measure of the vulnerability of a stock to fishing, which is then considered within the overall weight of evidence assessment of stock status.

The sections below outline the PSA scores for the blue swimmer crab targeted in each fishing sector; both commercial and recreational, in south-west WA.

9.3.6.1 Productivity

For the purposes of the PSA analysis, productivity scores are attributed to the species *Portunus armatus* and relevant and applicable to all fisheries. Both the commercial and recreational sectors are considered in the susceptibility scores and PSA analyses. Key factors influencing the score for productivity for *P. armatus* are short longevity (and thus low age at maturity), high fecundity, broadcast spawning strategy, and mid-trophic level. Density dependence is uncertain as there is no clear evidence for either compensatory or depensatory dynamics. Therefore, a precautionary approach has been taken and moderate score allocated. The total productivity score for this species averaged 1.33 (Table 9.2).

Table 9.2. PSA productivity scores for blue swimmer crab Portunus armatus in all fisheries targeting the resource in the West Coast Bioregion.

Productivity attribute	Score
Average maximum age	1
Average age at maturity	1
Reproductive strategy	1
Fecundity	1
Trophic level	2
Density dependence	2
Total productivity (average)	1.33

9.3.6.2 Susceptibility

9.3.6.2.1 Warnbro Sound and the Mandurah to Bunbury Developing Crab Fishery

Given the susceptibility scores for crab stocks in WS and MBDCF, the WSCMF scored a total susceptibility of 1.58 compared to 1.88 for the MBDCF. Their recreational fisheries scored 1.88 (Table 9.3; see Section 6.3.4 and Appendix 1 for justifications of susceptibility scores). The overall weighted PSA score was 2.18, and the MSC PSA-derived score was 92 (= low risk).

Table 9.3 PSA susceptibility scores for each sector that impacts on Portunus armatus in Warnbro Sound (WS) and the Mandurah to Bunbury Developing Crab Fishery (Area 1 - Comet Bay and Area 2 - Mandurah to Bunbury; MBDCF) which for the purpose of PSA analysis have been regarded as one stock.

Susceptibility attribute	Commercial Fisheries		Recreational Fishery
	WS	MBDCF	
Areal overlap	2	3	3
Vertical overlap	3	3	3
Selectivity	2	2	2
Post-capture mortality	2	2	2
Total susceptibility (multiplicative)	1.58	1.88	1.88

9.3.6.2.2 Hardy Inlet

The HI for the purpose of PSA analysis has been deemed the same stock as that in the WSCMF and MBDCF and scored 1.88 for susceptibility for both the commercial and recreational sectors (Table 9.4). Key factors influencing the score for susceptibility include high availability (areal overlap), high encounterability (vertical overlap), and medium selectivity and post-release mortality. The overall weighted PSA score for this stock was 2.17 and the MSC PSA-derived score was 92 (= low risk).

Table 9.4 PSA susceptibility scores for the sector that impact on Portunus armatus in the Hardy Inlet, which for the purpose of PSA analysis has been regarded as a single stock.

Susceptibility attribute	Commercial	Recreational
Areal overlap	**3**	**3**
Vertical overlap	**3**	**3**
Selectivity	**2**	**2**
Post-capture mortality	**2**	**2**
Total susceptibility (multiplicative)	**1.88**	**1.88**

9.3.6.3 Conclusion

Based on the productivity and susceptibility scores, the overall weighted (by fishery / sector catches) PSA scores for *Portunus armatus* in WSCMF, MBDCF and the HI were 2.18 and 2.17, respectively, which represents a low risk to both stocks.

Warnbro Sound and Mandurah-Bunbury Developing Crab Fishery	The biological characteristics of *P. armatus* including rapid growth, short lifespan, high fecundity, early maturity and broadcast spawning strategy, suggest this highly productive species has a low-moderate vulnerability to fishing (productivity score 1.33). Susceptibility scores of 1.58 and 1.88 for the commercial fisheries of WSCMF and the MBDCF, respectively, and 1.88 for their recreational fisheries were based on moderate to high availability, encounterability, selectivity and post-release mortality. The overall PSA score was 2.18, with an MSC PSA-derived score of 92 (= low risk). The PSA analysis indicates that the risk of unacceptable stock depletion is low under current management arrangements and fishing effort. It assumes that the productivity of the stock is constant and not impacted by environmental conditions.
Hardy Inlet.	The biological characteristics of *P. armatus* including rapid growth, short lifespan, high fecundity, early maturity and broadcast spawning strategy, suggest this highly productive species has a low-moderate vulnerability to fishing (productivity score 1.33). A susceptibility score of 1.88 for both the commercial and recreational sector in the HI was based on moderate to high availability, encounterability, selectivity and post-release mortality. The overall PSA score was 2.17 with an MSC PSA-derived score of 92 (= low risk). The PSA analysis indicates that the risk of unacceptable stock depletion is low under current management arrangements and fishing effort. It assumes that the productivity of the stock is constant and not impacted by environmental conditions.

9.4 Stock Status Summary

Presented below is a summary of each line of evidence considered in the overall weight of evidence assessment of the stocks that comprise the minor blue swimmer crab fisheries in the WCB, followed by the management advice and recommendations for future monitoring of the species.

9.4.1 Weight of Evidence Risk Assessment

9.4.1.1 Warnbro Sound

Category	Lines of evidence (Consequence/Status)
Catch history	Recent catches in the WSCMF have remained low (~5 t; Figure 5.11), in part due to the current licensee spreading fishing effort between WS and Area 1 of the MBDCF. Total annual catch and effort for the 2018/19 season was 2.4 t from 2,460 traplifts, similar to the 3.6 t reported in 2017/18. Following recommendations from a management review of the south-west WA blue swimmer crab resource (DIPRD, 2018), the removal of commercial fishing effort from WS is due to be finalised in 2020 via a Voluntary Fishery Adjustment Scheme.
Spatial distribution trends	With little seasonal freshwater discharge into Warnbro Sound, the waters of the protected embayment remain marine. Consequently, commercial fishing occurs throughout the fishery with most effort focused in deeper waters in the centre of the embayment (~15-20 m) and the shallower fringing waters to the south. Male and female non-berried crabs were prevalent across all commercial monitoring trap lines sampled, whereas berried females were generally most abundant in the shallower waters fringing the central basin.
Commercial catch rates	After several years of stability (0.8-1.0 kg/traplift) from 2004/05 to 2007/08, the annual standardised blue swimmer crab catch rate in the WSCMF increased to a peak of 1.7 kg/traplift in 2011/12. However, a subsequent decline in catch rate to below the harvest strategy limit triggered a review in 2014/15 that led to a voluntary closure for 7 months. Fishing recommenced for the 2015/16 season, with annual catch rate (1.0 kg/trap) above the harvest strategy threshold. However, the catch rate again fell below the threshold in 2016/17 and 2017/18, then increased to above the threshold (0.82 kg/traplift) in 2018/19.
Productivity susceptibility analysis	The biological characteristics of *P. armatus* including rapid growth, short lifespan, high fecundity, early maturity and broadcast spawning strategy, suggest this highly productive species has a low-moderate vulnerability to fishing (productivity score 1.33). Susceptibility scores of 1.58 and 1.88 for the commercial fisheries of WSCMF and the MBDCF, respectively, and 1.88 for their recreational fisheries were based on moderate to high availability, encounterability, selectivity and post-release mortality. The overall PSA score was 2.18, with an MSC PSA-derived score of 92 (= low risk). The PSA analysis indicates that the risk of unacceptable stock depletion is low under current management arrangements and fishing effort. It assumes that the productivity of the stock is constant and not impacted by environmental conditions.

Warnbro Sound Risk Matrix

Consequence (Stock Depletion) Level	Likelihood				Risk Score
	L1 Remote (<5%)	L2 Unlikely (5- <20%)	L3 Possible (20- <50%)	L4 Likely (≥50%)	
C1 Minimal		x			2
C2 Moderate	x				2
C3 High	NA				0
C4 Major	NA				0

C1 (Minimal Depletion): **Unlikely L2** – Given that commercial fishing will be removed in WS by 2020, and that recreational fishing in this embayment is currently considered to be minimal, it is unlikely that crab stocks in WS are being fished at unsustainable levels.

C2 (Moderate Depletion): **Likely L4** – There is a remote chance that a substantial increase in commercial and recreational fishing may cause moderate depletion of blue swimmer crab stock levels in WS due to the closure of the commercial fishery in 2020 and historically low levels of recreational fishing.

C3 (High Depletion): **NA** – Not plausible given available lines of evidence.

C4 (Major Depletion): **NA** – Not plausible given available lines of evidence.

Please note this risk assessment is current as of 2019, and does not take into account historically high levels of fishing pressure (2008/09-2013/14) prior to the cessation of the commercial fishery that led to a voluntary 9-month closure in 2014/15.

9.4.1.2 Mandurah to Bunbury Developing Crab Fishery

Category	**Lines of evidence (Consequence/Status)**
Catch history	Annual commercial blue swimmer catch from the MBDCF has fluctuated (2-30 t) since its inception in 2002, with changes in catch largely reflecting effort. Following a peak of 29.6 t in 2010, annual catch has declined steadily, partly due to minimal fishing effort in Area 2, and a reduction in effort in Area 1 as the fisher spread effort with an endorsement to fish crabs in WS. Total annual catch and effort for 2019 was 2.4 t from 8,670 traplifts, similar to the 2.9 t reported in 2018. Following recommendations from a management review of the south-west WA blue swimmer crab resource (DPIRD, 2018), the removal of all commercial fishing effort from the MBDCF is due to be finalised in 2020 via a Voluntary Fishery Adjustment Scheme.

Category	Lines of evidence (Consequence/Status)
Spatial distribution trends	Prior to 2016, trap fishing in CB was restricted to a narrow strip along the shore, but expanded into deeper waters following the closure of Zone D of the South West Trawl Managed Fishery. No distinct seasonal fishing pattern is apparent. Catch rates of male and female non-berried crabs were reasonably berried females were most abundant in southern, nearshore waters of the embayment. Commercial trapping for blue swimmer crabs in MB is concentrated in nearshore waters (<1 km from shore) between White Hill and Binningup. Catch rates of male and female non-berried crabs were reasonably consistent across all commercially fished areas in MB, whereas berried females were typically most abundant in northern coastal waters of the fishery.
Commercial catch rates	Following a gradual increase in annual standardised blue swimmer crab catch rate for CB from 0.3 kg/traplift in 1998 to 0.8 kg/traplift in 2004, catch rates have been relatively stable. The 2019 catch rate (0.9 kg/traplift) represents the highest annual standardised catch rate recorded since 1998. Following a sharp increase in annual standardised catch rate for MB from 2003 (0.8 kg/traplift) to 2004 (2.1 kg/traplift), catch rates over the next 7 years were relatively stable (1.6-2.2 kg/traplift). A decline in catch rate to just 0.4 kg/traplift occurred in 2014, which was substantially below the harvest strategy limit (1.1 kg/traplift). There has been no commercial fishing for blue swimmer crabs since 2014.
Productivity susceptibility analysis	The biological characteristics of *P. armatus* including rapid growth, short lifespan, high fecundity, early maturity and broadcast spawning strategy, suggest this highly productive species has a low-moderate vulnerability to fishing (productivity score 1.33). Susceptibility scores of 1.58 and 1.88 for the commercial fisheries of WSCMF and the MBDCF, respectively, and 1.88 for their recreational fisheries were based on moderate to high availability, encounterability, selectivity and post-release mortality. The overall PSA score was 2.18, with an MSC PSA-derived score of 92 (= low risk). The PSA analysis indicates that the risk of unacceptable stock depletion is low under current management arrangements and fishing effort. It assumes that the productivity of the stock is constant and not impacted by environmental conditions.

Mandurah to Bunbury Developing Crab Fishery Risk Matrix

Consequence (Stock Depletion) Level	Likelihood				Risk Score
	L1 Remote (<5%)	L2 Unlikely (5- <20%)	L3 Possible (20- <50%)	L4 Likely (≥50%)	
C1 Minimal	x				1
C2 Moderate	NA				0
C3 High	NA				0
C4 Major	NA				0

C1 (Minimal Depletion): **Remote L1** – Given that commercial fishing will be removed in the MBDCF by 2020, and that recreational fishing in CB and along the coastline between Mandurah and Bunbury is negligible, there is only a remote likelihood that crab stocks in MBDCF are being fished at unsustainable levels.

C2 (Moderate Depletion): **NA** – Not plausible given available lines of evidence.

C3 (High Depletion): **NA** – Not plausible given available lines of evidence.

C4 (Major Depletion): **NA** – Not plausible given available lines of evidence.

9.4.1.3 Area 3 of the West Coast Estuarine Managed Fishery (Hardy Inlet)

Category	Lines of evidence (Consequence/Status)
Catch history	Landings of blue swimmer crabs from the HI were first reported in 2005, with subsequent annual catches (<1.3 t) minimal compared to other WA fisheries. An exemption was issued in 2015 to trial traps to target blue swimmer crabs in HI. However, commercial trap catch and effort has been minimal with no reported catch since 2016.
Commercial catch rates	Commercial blue swimmer crab catch rates for HI are much lower than other WCB commercial fisheries, possibly because crabs are generally not targeted, but rather retained as a by-product of the fisher's netting activity that targets finfish species. Nominal annual commercial catch rates of 4-11 kg/day were reported between 2005-08 and a substantial increase to 62 kg/fisher day was recorded in 2010. Catch rates returned to historical levels (~3-9 kg/fisher day) between 2013 and 2016. No landings of blue swimmer crabs have been reported in HI since 2016.
Productivity susceptibility analysis	The biological characteristics of *P. armatus* including rapid growth, short lifespan, high fecundity, early maturity and broadcast spawning strategy, suggest this highly productive species has a low-moderate vulnerability to fishing (productivity score 1.33). A susceptibility score of 1.88 for both the commercial and recreational sector in the HI was based on moderate to high availability, encounterability, selectivity and post-release mortality. The overall PSA score was 2.17 with an MSC PSA-derived score of 92 (= low risk). The PSA analysis indicates that the risk of unacceptable stock depletion is low under current management arrangements and fishing effort. It assumes that the productivity of the stock is constant and not impacted by environmental conditions.

Commercial blue swimmer crab catch rates reported for HI are typically much lower than in other WCB commercial fisheries, possibly because crabs are typically retained as a by-product of the fisher's netting activity that targets finfish species. Furthermore, inter-annual blue swimmer crab abundance in this fishery is assumed to be largely driven by environmental influences, primarily the strength of the warm, southward-flowing Leeuwin Current, as HI is at the southern extremity of the species' distribution.

Hardy Inlet Risk Matrix

Consequence (Stock Depletion) Level	Likelihood				Risk Score
	L1 Remote (<5%)	L2 Unlikely (5- <20%)	L3 Possible (20- <50%)	L4 Likely (≥50%)	
C1 Minimal		x			2
C2 Moderate	x				2
C3 High	NA				0
C4 Major	NA				0

C1 (Minimal Depletion): **Unlikely L2** – Given that both commercial and recreational fishing in HI is considered to be minimal, and that stock abundance is largely environmentally driven, it is unlikely that crab stocks in HI are being fished at unsustainable levels.

C2 (Moderate Depletion): **Likely L4** – There is a remote chance that a substantial increase in commercial and recreational fishing may cause moderate depletion of blue swimmer crab stock levels in HI.

C3 (High Depletion): **NA** – Not plausible given available lines of evidence.

C4 (Major Depletion): **NA** – Not plausible given available lines of evidence.

9.4.1.4 Current Risk Status

9.4.1.4.1 Warnbro Sound

Based on the above lines of evidence, the current risk level for the WS blue swimmer crab stock is considered to be NEGLIGIBLE (C1 × L2). Blue swimmer crab assemblages in WS overlap with many near shore and estuarine stocks along the south west coast and are therefore highly likely to be the same genetic stock, due to the migration of crabs between these water bodies. As winter rains flush mated, pre-spawn female crabs from PHE through CB and into WS, the targeting of blue swimmer crabs in WS was considered a risk to depletion of the PHE breeding stock. A management review focused on increasing protection of the south-west WA blue swimmer crab breeding stock at a whole of resource level was finalised in 2019, with one of the subsequent management changes mandating the removal of commercial fishing from WS through a Voluntary Fishery Adjustment Scheme (VFAS) in 2020 (DPIRD, 2018). Furthermore, recreational fishing for blue swimmer crabs in WS is currently considered to be minimal. On this basis, the crab stock in WS is classified as **Sustainable.**

9.4.1.4.2 Mandurah to Bunbury Developing Crab Fishery

Based on the above lines of evidence, the current risk level for the MBDCF blue swimmer crab stock is considered to be NEGLIGIBLE (C1 × L1). Blue swimmer crab assemblages in CB and MB and the PHE are highly likely to be the same genetic stock, due to the migration of crabs between these water bodies. As winter rains flush mated, pre-spawn female crabs from PHE into CB and the nearshore waters of MB, the targeting of blue swimmer crabs in MBDCF was considered a risk to depletion of the PHE breeding stock. A management review focused on increasing protection of the south-west WA blue swimmer crab breeding stock at a whole of resource level was finalised in 2019, with one of the subsequent management changes mandating the removal of commercial fishing from MB through a Voluntary Fishery Adjustment Scheme (VFAS) in 2020 (DPIRD, 2018). Furthermore, recreational fishing for blue swimmer crabs in WS is currently considered to be negligible. On this basis, the crab stock in MB is classified as **Sustainable.**

9.4.1.4.3 Area 3 of the West Coast Estuarine Managed Fishery (Hardy Inlet)

Based on the above lines of evidence, the current risk level for the HI blue swimmer crab stock is considered to be NEGLIGIBLE (C1 × L2). Commercial blue swimmer crab catch rates reported for HI are typically much lower than in other WCB commercial fisheries, possibly because crabs are typically retained as a by-product of the fisher's netting activity that targets finfish species. Furthermore, inter-annual blue swimmer crab abundance in this fishery is assumed to be largely driven by the strength of the warm, southward-flowing Leeuwin Current, as HI is at the southern extremity of the tropical species' distribution. Furthermore, recreational fishing for blue swimmer crabs in HI is considered to be minimal and driven by environmentally driven stock abundance. On this basis, the crab stock in HI is classified as **Sustainable.**

9.4.1.5 Future Monitoring

As commercial fishing in the WSCMF and MBDCF is expected to cease in 2020, an alternative to the current assessment of breeding stock levels using commercial catch and effort and commercial monitoring data will need to be developed. Current alternatives under consideration include exemptions for PHE commercial fishers to undertake breeding stock surveys under the Department of Primary Industry and Regional Development (DPIRD) supervision, and DPIRD fishery-independent breeding stock surveys replicating those currently undertaken in the LE and GB. However, any future monitoring for these fisheries will need to be assessed in relation to the social and economic value of each crab resource and the importance of the breeding stock in these areas to the recruitment in PHE.

Assessment of the HI blue swimmer crab stock will continue to be based on reported commercial catch and effort data.

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Appendix 1

Justification for Harvest Strategy Reference Levels

The performance indicator used to evaluate the stock status of *P. armatus* in the [Region] is spawning biomass (*B*), or an appropriate proxy such as spawning potential ratio (SPR) (see Table A1.1). For each stock, the performance indicator is estimated periodically (at least every 5 years) and compared to associated reference levels (Table A1.1). The reference levels are consistent with those used by the Department in other similar assessments and are based on internationally accepted benchmarks for moderate to long-lived fish species (Mace 1994; Caddy and Mahon 1995; Gabriel and Mace 1999; Wise *et al*. 2007). Note that the threshold level of B_{30} (and SPR_{30}) corresponds to B_{MSY} (Table A1.1).

Table A1.1. Performance indicators and associated reference levels used to evaluate the status of indicator species and secondary indicator species in the Pilbara and Kimberley

	Reference Levels		
Performance Indicator	**Target**	**Threshold (B_{MSY})**	**Limit**
Spawning biomass (*B*)	B_{40}	B_{30}	B_{20}
Spawning potential ratio (SPR)	SPR_{40}	SPR_{30}	SPR_{20}

Appendix 2

Consequence, Likelihood and Risk Levels (based on AS 4360 / ISO 31000) modified from Fletcher *et al*. (2011) and Fletcher (2015)

CONSEQUENCE LEVELS

As defined for major target species

1. Minor – Fishing impacts either not detectable against background variability for this population; or if detectable, minimal impact on population size and none on dynamics

   Spawning biomass > Target level (B_{MEY})

2. Moderate – Fishery operating at maximum acceptable level of depletion

   Spawning biomass < Target level (B_{MEY}) but > Threshold level (B_{MSY})

3. High – Level of depletion unacceptable but still not affecting recruitment levels of stock

   Spawning biomass < Threshold level (B_{MSY}) but >Limit level (B_{REC})

4. Major – Level of depletion is already affecting (or will definitely affect) future recruitment potential/ levels of the stock

   Spawning biomass < Limit level (B_{REC})

LIKELIHOOD LEVELS

These are defined as the likelihood of a particular consequence level actually occurring within the assessment period (5 years was used)

1. Remote – The consequence has never been heard of in these circumstances, but it is not impossible within the time frame (Probability of <5%)
2. Unlikely – The consequence is not expected to occur in the timeframe but it has been known to occur elsewhere under special circumstances (Probability of 5 - <20%)
3. Possible – Evidence to suggest this consequence level is possible and may occur in some circumstances within the timeframe. (Probability of 20 - <50%)
4. Likely – A particular consequence level is expected to occur in the timeframe (Probability of ≥50%)

Consequence × Likelihood Risk Matrix		Likelihood			
		Remote (1)	Unlikely (2)	Possible (3)	Likely (4)
Consequence	Minor (1)	Negligible	Negligible	Low	Low
	Moderate (2)	Negligible	Low	Medium	Medium
	High (3)	Low	Medium	High	High
	Major (4)	Low	Medium	Severe	Severe

Risk Levels	Description	Likely Reporting & Monitoring Requirements	Likely Management Action
1 Negligible	Acceptable; Not an issue	Brief justification – no monitoring	Nil
2 Low	Acceptable; No specific control measures needed	Full justification needed – periodic monitoring	None specific
3 Medium	Acceptable; With current risk control measures in place (no new management required)	Full Performance Report – regular monitoring	Specific management and/or monitoring required
4 High	Not desirable; Continue strong management actions OR new / further risk control measures to be introduced in the near future	Full Performance Report – regular monitoring	Increased management activities needed
5 Severe	Unacceptable; If not already introduced, major changes required to management in immediate future	Recovery strategy and detailed monitoring	Increased management activities needed urgently

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Appendix 3

Productivity Susceptibility Analysis (PSA) Scoring Tables

Productivity attribute	**High productivity Low risk Score = 1**	**Medium productivity Medium risk Score = 2**	**Low productivity High risk Score = 3)**
Average maximum age	<10 years	10-25 years	>25 years
Average age at maturity	<5 years	5-15 years	>15 years
Average maximum size (not to be used when scoring invertebrates)	<1000 mm	1000-3000 mm	>3000 mm
Average size at maturity (not to be used when scoring invertebrates)	<400 mm	400-2000 mm	>2000 mm
Reproductive strategy	Broadcast spawner	Demersal egg layer	Live bearer
Fecundity	>20,000 eggs per year	100-20,000 eggs per year	<100 eggs per year
Trophic level	<2.75	2.75-3.25	>3.25
Density dependence (only to be used when scoring invertebrates)	Compensatory dynamics at low population size demonstrated or likely	No depensatory or compensatory dynamics demonstrated or likely	Depensatory dynamics at low population sizes (Allele effects) demonstrated or likely

Susceptibility attribute	**Low susceptibility Low risk Score = 1**	**Medium susceptibility Medium risk Score = 2**	**High susceptibility High risk Score = 3)**
Areal overlap (availability) i.e. overlap of fishing effort with stock distribution	<10% overlap	10-30% overlap	>30% overlap
Encounterability i.e. the position of the species / stock within the water column / habitat relative to the position of the fishing gear	Low encounterability / overlap with fishing gear	Medium overlap with fishing gear	High encounterability / overlap with fishing gear (Default score for target species in a fishery)
Selectivity of gear type i.e. potential of gear to retain species	a) Individual < size at maturity are rarely caught	a) Individual < size at maturity are regularly caught	a) Individual < size at maturity are frequently caught
	b) Individual < size can escape or avoid gear	b) Individual < half the size can escape or avoid gear	b) Individual < half the size are retained by gear

Post-capture mortality i.e. the chance that, if captured, a species would be released and that it would be in a condition permitting subsequent survival	Evidence of majority released post-capture and survival	Evidence of some released post-capture and survival	Retained species or majority dead when released