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Blue Crab (*Portunus armatus*) Fishery 2018/19

C. L. Beckmann, C. Noell and G. E. Hooper

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SARDI Aquatics Sciences
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May 2020

Fishery Assessment Report to PIRSA Fisheries and Aquaculture

SOUTH AUSTRALIA

Government of South Australia
Primary Industries and Regions SA

SARDI
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Funds for this research were provided by Primary Industries and Regions South Australia (PIRSA) Fisheries and Aquaculture, obtained through licence fees. The South Australian Research and Development Institute (SARDI) Aquatic Sciences provided substantial in-kind support. Dennis Holder and Garry Barnes provided their crew and vessel for the 2018/19 fishery-independent survey. Fieldwork was undertaken by Graham Hooper. The catch and effort data from the SARDI Information Management System were provided by Melleessa Boyle of the Information Systems and Database Support Unit at SARDI Aquatic Sciences. This report was formally reviewed by Dr Ben Stobart and Dr Katherine Heldt of SARDI Aquatic Sciences, and Keith Rowling of PIRSA Fisheries and Aquaculture, and approved for release by Dr Stephen Mayfield, Science Leader, Fisheries (SARDI Aquatic Sciences).

EXECUTIVE SUMMARY

This report assesses the current status of the Blue Swimmer Crab (*Portunus armatus*) resource and provides the latest estimates of the biological performance indicators (PIs), information in context of the reference points (RPs) and stock status classification described in the draft Management Plan for the Blue Crab Fishery (BCF). The harvest strategy for the fishery was developed in accordance with the National Fishery Status Reporting Framework classification system to determine the status of all South Australian fish stocks.

The current Management Plan for the BCF outlines the decision rules for classifying stock status of the Spencer Gulf (SG) and Gulf St Vincent (GSV) Management Zones relative to limit, trigger and target RPs defined for the primary PI, which is legal-size catch per unit effort (CPUE) previously calculated from the June/July fishery-independent survey (FIS; PIRSA 2018). In 2019 a revised harvest strategy was developed, this includes PIs and associated RPs that reflect CPUE during March/April FIS to allow for timely decision making in relation to setting a total allowable commercial catch (TACC). Decision rules have also been updated to reflect reconstructed indicators for March/April CPUE and are reported on here.

Spencer Gulf

In 2018/19, 97% of the SG component of the TACC (382 t) was harvested by the BCF. Commercial CPUE was the fourth highest on record for catch-per-potlift. Data from the March 2019 FIS indicated that pre-recruit CPUE has continued to decline since 2016, with the 2019 value the lowest observed for March/April. The FIS CPUE of legal-size crabs increased by 104% compared to 2018 and was the highest recorded for March/April. In 2019, legal-size FIS CPUE in SG was 5.3 ± 0.1 kg.potlift^{-1}, which was above the trigger RP (2.4 kg.potlift^{-1}) defined for this PI. As a result, the SG blue swimmer crab stock is classified as '**sustainable**'.

Gulf St Vincent

The GSV component of the annual TACC (245 t) was fully harvested in 2018/19, with commercial CPUE the third highest on record for catch-per-day and the fourth highest on record for catch-per-potlift. Data from the March 2019 FIS indicated that pre-recruit and legal-size CPUE were the second highest recorded for March/April. Between 2017 and 2019, FIS CPUE increased by 25% for pre-recruit crabs and 8% for legal-size crabs. In 2019, legal-size FIS CPUE in GSV was 4.8 ± 0.2 kg.potlift^{-1}, which was above the trigger RP (1.7 kg.potlift^{-1}) defined for this PI. As a result, the GSV blue swimmer crab stock is classified as '**sustainable**'.

Table 1. Key Blue Crab Fishery statistics for the 2018/19 season.

Statistic	Spencer Gulf	Gulf St Vincent
Total catch	371 t (97% TACC)	245 t (100% TACC)
Commercial CPUE	3.9 ± 0.1 kg.potlift^{-1} (567 kg.boat day^{-1})	3.9 ± 0.1 kg.potlift^{-1} (536 kg.boat day^{-1})
March Legal-size FIS CPUE	5.3 ± 0.1 kg.potlift^{-1}	4.8 ± 0.2 kg.potlift^{-1}
March Pre-recruit FIS CPUE	1.4 ± 0.1 kg.potlift^{-1}	0.5 ± 0.0 kg.potlift^{-1}
Status	**Sustainable**	**Sustainable**

Abbreviations- total allowable commercial catch (TACC), catch per unit effort (CPUE), Fishery-independent survey (FIS).

Keywords: Blue Crab, Fishery stock assessment, stock status, catch per unit effort (CPUE).

1. INTRODUCTION

1.1. Overview

Stock assessments for the South Australian Blue Crab Fishery (BCF) have been produced annually since 2004 (Svane and Hooper 2004) as part of the South Australian Research and Development Institute (SARDI) Aquatic Sciences' ongoing assessment program. The fishery targets Blue Swimmer Crabs, *Portunus armatus* (formerly *P. pelagicus*; Lai *et al.* 2010), hereafter referred to as Blue Crabs.

1.2. Aims and objectives

This report has four aims: 1) to present information on the fishery and biology of the species; 2) to assess the current status of the Blue Crab resource in Spencer Gulf (SG), and Gulf St. Vincent (GSV), and consider the uncertainty associated with each assessment; 3) to comment on the current biological performance indicators (PIs) and reference points (RPs) for the fishery; and 4) to identify future directions for the research program.

1.3. Description of the fishery

1.3.1. Access

Blue Crabs support an important inshore fishery in South Australia with the South Australian commercial Blue Crab Fishery valued at $7.8 million (gross value of production; GVP) in 2017/18 (Econsearch, 2019).

There are three major stakeholders: the commercial pot fishery (Figure 1.1), the commercial Marine Scalefish Fishery (MSF; Figure 1.2) and the recreational fishery. Access to take Blue Crabs in the area of the BCF (SG and GSV zones) is provided via a BCF or a MSF licence endorsed with BCF quota entitlements. MSF licences are also permitted to take Blue Crabs on the West Coast (WC) of South Australia (west of longitude 135°E). Effectively the MSF is confined to the WC, therefore it is considered separately to the BCF, which is a quota management system with a total allowable commercial catch (TACC). BCF licence holders (pot fishers) generally fish in waters deeper than those fished by MSF licence holders endorsed with BCF quota units or recreational fishers allowing extended seasonal access to crabs during the cooler months of the year. Areas closed to fishing include Marine Park sanctuary zones, restricted access zones, upper SG, Whyalla, Port Broughton and Fisherman's Bay (Figure 1.1; PIRSA 2018).

Commercial pot fishers generally haul their gear once or twice every 24 hours using specifically designed crab pots covered with mesh. MSF operators mostly use hoop/drop nets

or dab nets. Recreational fishers mostly use hoop/drop nets or hand held rakes. Current output controls for Blue Crabs caught in South Australia include restrictions on the total commercial catch through a TACC quota system, spatial and temporal commercial closures, bag and boat limits for recreational fishers, a minimum legal size limit (MLS) of 110 mm carapace width (CW) measured from the anterior base of the first spine, and restrictions on taking berried females.

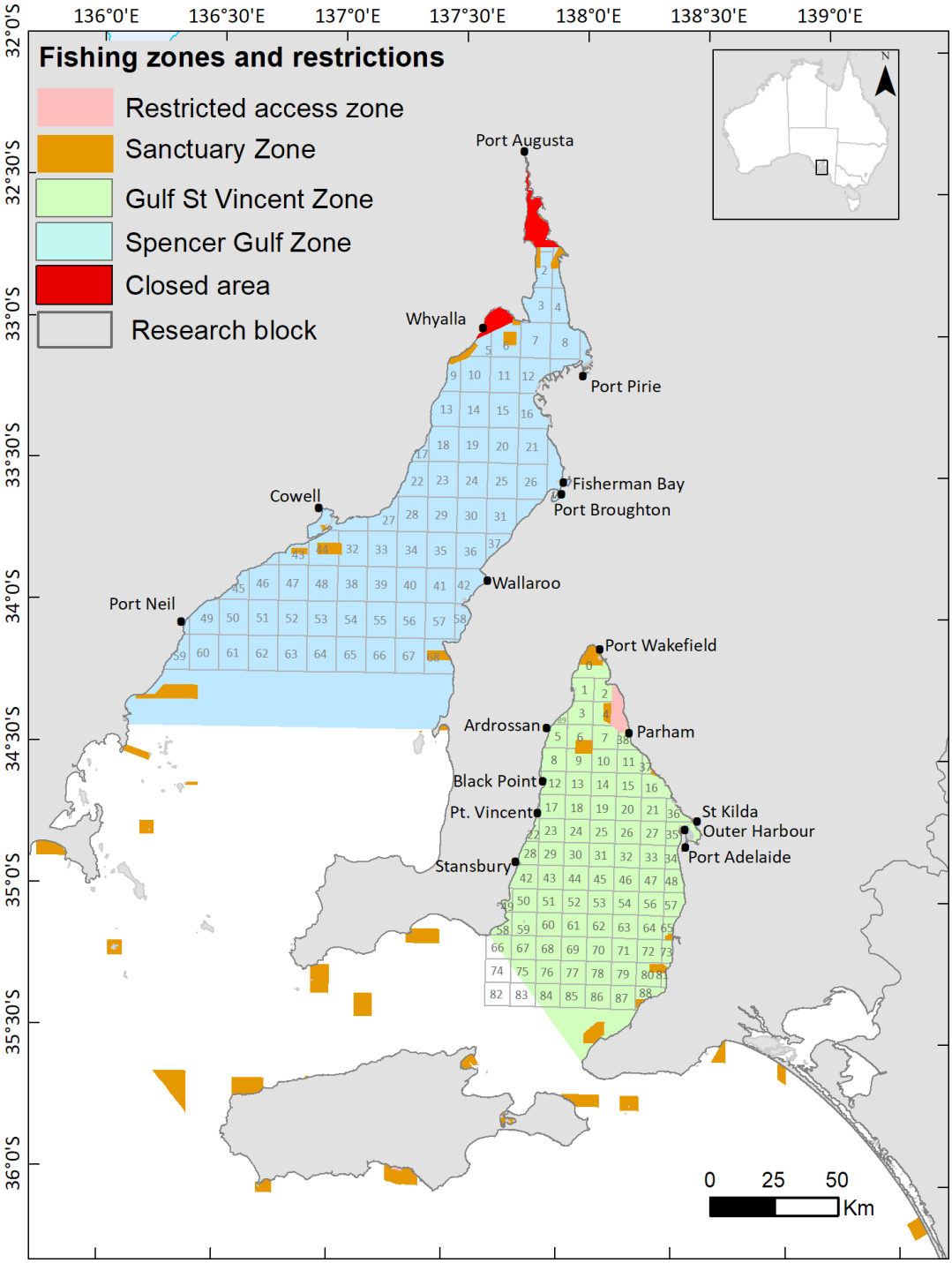

Figure 1.1 The South Australian Blue Crab Fishery with Spencer Gulf and Gulf St Vincent fishing zones, research blocks and restrictions including closed areas, restricted access and Sanctuary Zones.

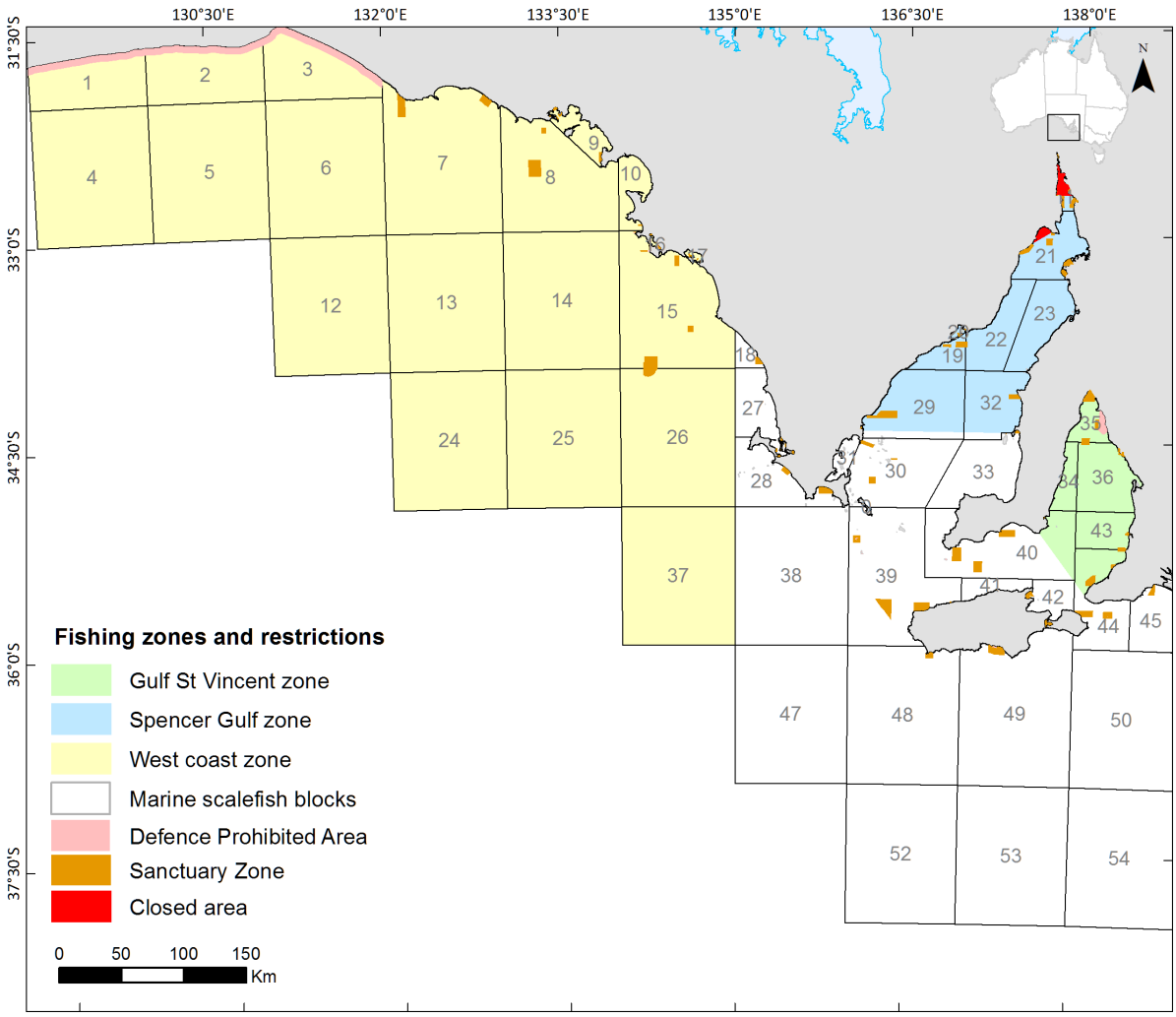

Figure 1.2 South Australian Marine Scalefish Fishery fishing zones, research blocks and restrictions including closed areas, restricted access and Sanctuary Zones. The Gulf St Vincent and Spencer Gulf zones are part of the Blue Crab Fishery, and the West Coast zone (not subject to total allowable catch) operates in all waters west of longitude 135° East.

1.3.2. Management arrangements

The BCF is managed by Primary Industries and Regions South Australia (PIRSA) Fisheries and Aquaculture and was established in 1996. The *Fisheries Management Act 2007* provides the statutory framework for management of the resource. The schemes of management for the fishery are prescribed in the *Fisheries Management (Blue Crab Fishery) Regulations 2013* and the *Fisheries Management (Marine Scalefish Fisheries) Regulations 2017*. General regulations pertaining to commercial and recreational take of Blue Crabs are described in the *Fisheries Management (General) Regulations 2017*.

Formalised management arrangements for the BCF include pot dimension restrictions, pot to quota unit ratios, delineation of two fishing zones, one in SG and one in GSV, and a TACC with quota units allocated separately for each zone. Quota units are transferable between the pot fishers of the BCF and eligible MSF licence holders, but only within the same zone. Since

the introduction of annual TACC setting in the BCF, there has been a transfer of fishing effort from the MSF to the pot fishing sector, with the number of MSF licences holding Blue Crab TACC steadily decreasing. Since 2010/11, there has been no MSF effort in GSV and a single licence holder operating in SG since 2002/03.

The State-wide annual TACC for the BCF was initially set at 520 t for the 1996/97 fishing season (325 t in SG and 194 t GSV). Over the following four seasons the annual TACC was gradually increased to 627 t (382 t in SG and 245 t in GSV) in 2000/01, where it remained until 2012/13. In 2013/14 and 2014/15, the annual TACC for the GSV zone was reduced to 196 t due to stock sustainability concerns (Beckmann and Hooper 2016). A voluntary commercial closure in GSV was also implemented from 1 July 2013 to 15 January 2014. From 2015/16, stock levels increased and as a result, the annual TACC for the GSV zone was returned to the baseline level of 245 t, resulting in an overall TACC of 627 t (382 t in SG and 245 t in GSV).

Prior to 2013/14, recreational fishers were restricted to a bag limit of 40 crabs (blue crabs and/or sand crabs combined) per person per day and a boat limit of 120 crabs per day (where 3 or more people are on board). Concurrent with the reduction in quota for the GSV zone of the BCF during 2013/14, recreational bag and boat limits for GSV were temporarily reduced by 50%, to 20 and 60 crabs per day, respectively. Following a review of recreational bag and boat limits, from December 2016 a bag limit of 20 crabs (Blue Crabs and/or Sand Crabs combined) per person per day and a boat limit of 60 crabs per day was implemented across the entire State.

The BCF fishing zones are subject to annual temporal closures. Prior to 2004/05, the closure in SG was during December and January. However, this was modified to 21 December to 19 February to take advantage of higher market prices in the lead up to Christmas. The GSV zone is closed between 1 November and 15 January.

Temporary spatial fishing closures have been in place in the GSV zone of the BCF since January 2014 to allow greater recreational access to Blue Crabs during the peak recreational period (i.e. January and Easter). The commercial closures operate in GSV between St Kilda Beach and the northern Outer Harbor breakwater and the southern Outer Harbor breakwater to Marino Rocks. A temporary closure also applies to a two nm area adjacent to Ardrossan, Black Point, Port Vincent, and Stansbury boat ramps.

From 2015/16 to 2018/19, a closed-season commercial fishing trial was undertaken at the request of the South Australian Blue Crab Pot Fishers Association (SABCPFA) in the GSV zone of the BCF. In 2016/17, the trial was extended to include SG; however, this only occurred

for one year. This temporary fishing trial was supported by PIRSA Fisheries and Aquaculture and an exemption was issued with conditions including; (i) spatial and temporal restrictions; (ii) limitations on total catch relative to amounts of annual TACC held by licence holders; (iii) continued collection and reporting of data using the current research framework; (iv) collection of additional finer scale spatial information and; (v) collection of additional economic information on the value of catch.

Additional restrictions were introduced from March 2018 and these affected fishers operating out of the Port River. Restrictions were introduced in response to the detection of the Pacific Oyster Mortality Syndrome (POMS) in feral Pacific Oyster populations in the Port River. In order to reduce the risk of the inadvertent spread of POMS, two notices were issued on the 9th of March 2018 under Section 79 of the *Fisheries Management Act 2007.* Firstly, a ban on the removal of all bivalve filter-feeding organisms (oysters, mussels and cockles) from the Port River estuary (including the waters of West Lakes and North Arm to south of the breakwater at St Kilda). This notice is ongoing. Secondly, until the 6th of April 2018, there was a ban on fishing vessels that have been moored in the Port River entering a five nautical mile area around oyster leases in GSV and Kangaroo Island. This notice has since been revoked. These restrictions also affected on the March 2018 survey, which was not completed in GSV.

1.4. Biology of the Blue Crab

1.4.1. Distribution and habitat

Blue Crabs are distributed within near-shore, marine bays and estuarine systems in Australia and New Caledonia (Lai *et al*. 2010). They occur in a wide range of algal and seagrass habitats and on sandy and muddy substrata, from the intertidal zone to a depth of at least 50 m (Williams 1982; Edgar 1990). In coastal waters, smaller crabs are generally found in shallow waters < 1 m, while adults are found in deeper waters. Juvenile Blue Crabs live in mangrove creeks and mud flats for eight to twelve months, by which time they attain a size of 80 to 100 mm CW. The proportion of males in the catch has been shown to increase with depth from January to September and decrease with depth from October to December (Xiao and Kumar 2004). This is likely due to male and female crabs preferring different habitats at different times of the year.

1.4.2. Reproductive biology

Male and female Blue Crabs generally reach sexual maturity at similar CWs between 70 and 90 mm (Smith 1982). The spawning season lasts for three to four months over the summer/autumn period (Kumar *et al*. 2000). The duration of the growing season varies among individuals because Blue Crab larvae that settle onto the ocean floor in early summer have a

longer growing season than those settling in mid to late summer. In South Australian waters, Blue Crabs close to the MLS (110 mm CW) are ~14 to 18 months old, and sexually mature, with females producing at least two batches of eggs within one season. Fecundity of female Blue Crabs is size-dependent, increasing up to a CW of 134 mm and decreasing thereafter, with females producing between 650,000 and 1,760,000 eggs per spawning event (Kumar *et al.* 2000; 2003). From 105 mm to 125 mm, fecundity may increase by 84%, indicating that a single large female can produce as many eggs as two small females (Kumar *et al.* 2003).

In South Australia, late stages of ovarian development were observed in Blue Crabs during late October to November in conjunction with rising seawater temperatures (Kumar *et al.* 2000). During copulation, the spermatophore is transferred to the female spermatheca. The eggs are subsequently fertilised on extrusion (Smith 1982) and egg extrusion is independent of the timing of copulation. Van Engel (1958) found that, for another portunid, the Chesapeake Blue Crab *Callinectes sapidus*, the sperm in the female spermatheca could remain viable for at least 12 months. This is also likely to be the case for the South Australian Blue Crab.

1.4.3. Early life history

Blue Crab larvae mostly hatch in offshore areas during November to March (Bryars and Havenhand 2004). Larval dispersal is influenced by wind (strength and direction), and laboratory experiments suggest that temperature has a marked effect on larval development (Bryars and Havenhand 2006). In years of average seasonal temperature increases, the larval development durations range between 26 and 45 days, with a peak in post-larval settlement occurring between mid-January and mid-March.

1.4.4. Stock structure

Using allozyme markers, Bryars and Adams (1999) determined that the populations of Blue Crab within SG, GSV and WC regions of South Australia represented separate sub-populations with limited gene flow. They also found that inter-regional larval dispersal is restricted, and each sub-population is most likely dependent on its own larval supply. Analyses of microsatellites also suggested that Blue Crabs in different bays constituted genetically separate meta-populations in South Australia, which suggests that migration between these populations is limited.

1.5. Research program

Since 2004, fishery assessment reports have documented the biology and management of the BCF in South Australia, presented analyses of commercial logbook and FISs, and provided

assessment against the PIs of the Management Plan for the fishery (PIRSA 2012; 2018). Since 2008, the report has presented information for each fishing zone separately.

The research program comprises three components: 1) a FIS to inform fishing strategy decisions and assess the fishery against PIs in the Management Plan; 2) management of fishery-dependent commercial logbook data; and 3) production of an annual stock assessment report.

The annual stock assessment report is prepared for PIRSA Fisheries and Aquaculture, and informs management decisions in accordance with the TACC decision rules provided in the harvest strategy.

1.6. Management Plan

The Management Plan for the BCF (PIRSA 2018) is required under the *Fisheries Management Act 2007*. The current Management Plan for the BCF outlines the decision rules for classifying stock status of the SG and GSV Management Zones relative to limit, trigger and target RPs defined for the primary PI, which is legal-size CPUE, previously calculated from the June/July FIS (PIRSA 2018). In 2019 a revised harvest strategy was developed, this includes development of PIs and associated RPs that reflect CPUE during March/April FIS to allow for timely decision making in relation to setting a TACC (PIRSA 2019). Key biological PIs and RPs are used to guide the annual TACC decision-making process, which aims to adjust the TACC when indicators reflect increases or decreases in CPUE, which is a proxy for relative biomass. The primary biological PI to determine the annual TACC is legal-size CPUE (kg.potlift^{-1}) estimated from the March/April FIS (Table 1.1).

Table 1.1 Key biological performance indicators and reference points for the Spencer Gulf and Gulf St Vincent zones of the Blue Crab Fishery under the Draft Management Plan (PIRSA 2019). Abbreviation: Fishery-independent survey (FIS); catch per unit effort (CPUE); Spencer Gulf (SG); Gulf St Vincent (GSV).

Performance indicator	Gulf	Reference Point		
		Limit	Trigger	Target
FIS CPUE of legal-size crabs (kg.potlift^{-1})	SG	1.0	2.4	3.7
	GSV	0.8	1.7	2.5

1.7. Stock status classification

This stock assessment report assesses the current status of the Blue Crab (*Portunus armatus*) resource and provides the latest estimates of the biological PIs, within the context of the RPs and stock status classification in accordance with the BCF Management Plan. The harvest strategy for the fishery was developed in accordance with the National Fishery Status Reporting Framework (NFSRF; Flood *et al.* 2014, Stewardson *et al*. 2016) classification system to determine the status of all South Australian fish stocks. This framework was recently revised by Stewardson *et al.* (2018, Table 1.2).

The current status of the BCF was assessed against RPs, which are linked to stock status using a modified traffic light system. When legal-size CPUE is above the trigger RP, the relative biomass of legal-sized Blue Crabs is considered to be sustainable (green). When the legal-size CPUE is below the trigger RP, the relative biomass of Blue Crabs is considered to be depleting or recovering; yellow and orange, respectively. When legal-size CPUE is below the limit RP, the fishery is considered to be recruitment impaired or depleted (red).

Table 1.2 Stock status terminology (Stewardson *et al.* 2018).

	STOCK STATUS	DESCRIPTION	POTENTIAL IMPLICATIONS FOR MANAGEMENT OF THE STOCK
	Sustainable	Biomass (or proxy) is at a level sufficient to ensure that, on average, future levels of recruitment are adequate (recruitment is not impaired) and for which fishing mortality (or proxy) is adequately controlled to avoid the stock becoming recruitment impaired (overfishing is not occurring).	Appropriate management is in place
	Depleting	Biomass (or proxy) is not yet depleted and recruitment is not yet impaired, but fishing mortality (or proxy) is too high (overfishing is occurring) and moving the stock in the direction of becoming recruitment impaired.	Management is needed to reduce fishing mortality and ensure that the biomass does not become depleted.
	Recovering	Biomass (or proxy) is depleted and recruitment is impaired, but management measures are in place to promote stock recovery, and recovery is occurring.	Appropriate management is in place, and there is evidence that the biomass is recovering.
	Depleted	Biomass (or proxy) has been reduced through catch and/or non-fishing effects, such that recruitment is impaired. Current management is not adequate to recover the stock, or adequate management measures have been put in place but have not yet resulted in measurable improvements.	Management is needed to recover this stock; if adequate management measures are already in place, more time may be required for them to take effect.
	Undefined	Not enough information exists to determine stock status.	Data required to assess stock status are needed
	Negligible	Catches are so low as to be considered negligible and inadequate information exists to determine stock status.	Assessment will not be conducted unless catches and information increase

2. METHODS

2.1. Fishery-independent surveys

FIS are conducted using commercial industry vessels, in combination with independent on board observers. The primary aim of the FIS is to determine the relative abundance and size composition of Blue Crabs in SG and GSV. While there has been some inter-annual variability in the timing of the FIS, they have been generally undertaken during June and July (winter) in both gulfs from 2002–2018. June/July surveys were not undertaken in SG during 2011, 2013 and 2015 as in these years the CPUE of pre-recruits was above the average for the previous 10-years (PIRSA 2012). Full details of the June/July survey dates are available in Beckmann and Hooper (2019). Annual March/April surveys commenced in 2015 in GSV and in 2016 in SG. No survey was undertaken in GSV during March/April in 2018 due to the POMS outbreak. Full details of the March/April survey dates are available in Appendix A.

The area of the FIS encompasses waters with depths ranging from three to 22 m northwards of a line from Wallaroo to Cowell in SG, and northwards of a line from Glenelg to Port Vincent in GSV (Figure 2.1). Sampling locations were determined based on fisher knowledge and historical catch and effort data. From these recommendations, four FIS sites were selected in each fishing block. From 2003–07, the FIS design included 108 sites in SG and 92 sites in GSV. Note that in 2002 Fewer potlifts (~22% less in SG and 41% less in GSV) were undertaken compared to surveys undertaken during 2003–2007. In June 2008, the FIS design was modified by SARDI, PIRSA Fisheries and Aquaculture and industry to provide a more representative measure of relative abundance of Blue Crab in each gulf. Changes included removing all sampling locations from some fishing blocks, adding new FIS locations to previously un-surveyed blocks, and relocating sampling locations within existing blocks. The 2008–2015 FIS design included 108 sites in SG and 104 sites in GSV.

The Blue Crab Fishery Management Plan (PIRSA 2018) included a provision to investigate reducing the time lag between the FIS and the beginning of the TACC year. This was achieved by transitioning from June/July to March/April surveys. Because of this process, from 2016, the number of sites sampled during the FIS has been reduced to allow three paired surveys (June/July and March/April) to be undertaken and for PIs and associated RPs to be developed based on the March/April time series (PIRSA 2019).

March/April surveys commenced in 2015 in GSV and 2016 in SG. During 2015, 50 sites were sampled in March/April in GSV while the full survey design (108 sites) was maintained during June/July of 2015. From 2016, 60 survey sites per gulf were sampled during March/April and June/July (except in 2018 as the GSV survey was not undertaken during March/April). Figure

2.1 shows the sampling locations in the SG and GSV zones of the BCF. For the GSV zone, the reduction in sites sampled generally reflected the removal of sites in areas with consistently low abundance. A similar approach was undertaken in SG; however, site selection was restricted due to the large size of the study area.

At each FIS site, commercial and small-mesh pots were set and hauled on a daily basis. Commercial pots have increased in size, and larger mesh and escape gaps have become common since 2006/07. Since 2006/07, several operators have switched from single or double set pots to long–lines, where several pots are attached to a single line (Beckmann *et al.* 2015). CPUE estimates from commercial pots are presented in Appendix B. To standardise data collected in the FIS, research pots have remained unchanged with a diameter of 140 cm, a height of 50 cm, and a mesh size of 5.5 cm.

At each FIS site, five sets of gear were deployed, each set comprising of one commercial pot and one small-mesh pot (except for GSV in July 2012 when only small mesh pots were used). Each set of gear was spaced 150 m apart and, where both pot types were used, each pot was separated by 40 m of rope. Since June 2014, pots in GSV have been set along a single line (long line) at each FIS location with each set of gear spaced at 76 m apart. Pots were baited with fresh Australian Salmon, Australian Sardine or Striped Trumpeter and hauled from dawn each day. A global positioning system (GPS) was used to locate the gear, and depth was recorded at each FIS location. Carapace width (mm) of Blue Crabs was measured using Vernier callipers, and details of sex (male or female) and condition (dead, soft, berried) were recorded.

Nominal FIS CPUE is calculated as the average weight of legal-size and pre-recruit Blue Crabs per research potlift (small-mesh pots only). Sex- and gulf-specific weight conversions for each crab length measured were undertaken using the length weight relationship (Beckmann and Hooper, 2017). CPUE is presented for both gulfs using the historical FIS locations sampled since 2003 (52 sites in SG and 32 sites in GSV) and the 60 site design sampled since 2008 as per the harvest strategy. Size frequency information is presented as the sum of crabs caught per pot lift in specified length classes.

ArcGIS (ArcMap 10.1) software was used to depict the spatial patterns in crab abundance from 2009 to 2018. CPUE from each site was determined and the kernel density method was used to calculate the density of point features within each output raster cell (100 m * 100 m). A search radius of 7,500 m was used to generate kernel density maps (crabs.m^2) for both SG and GSV.

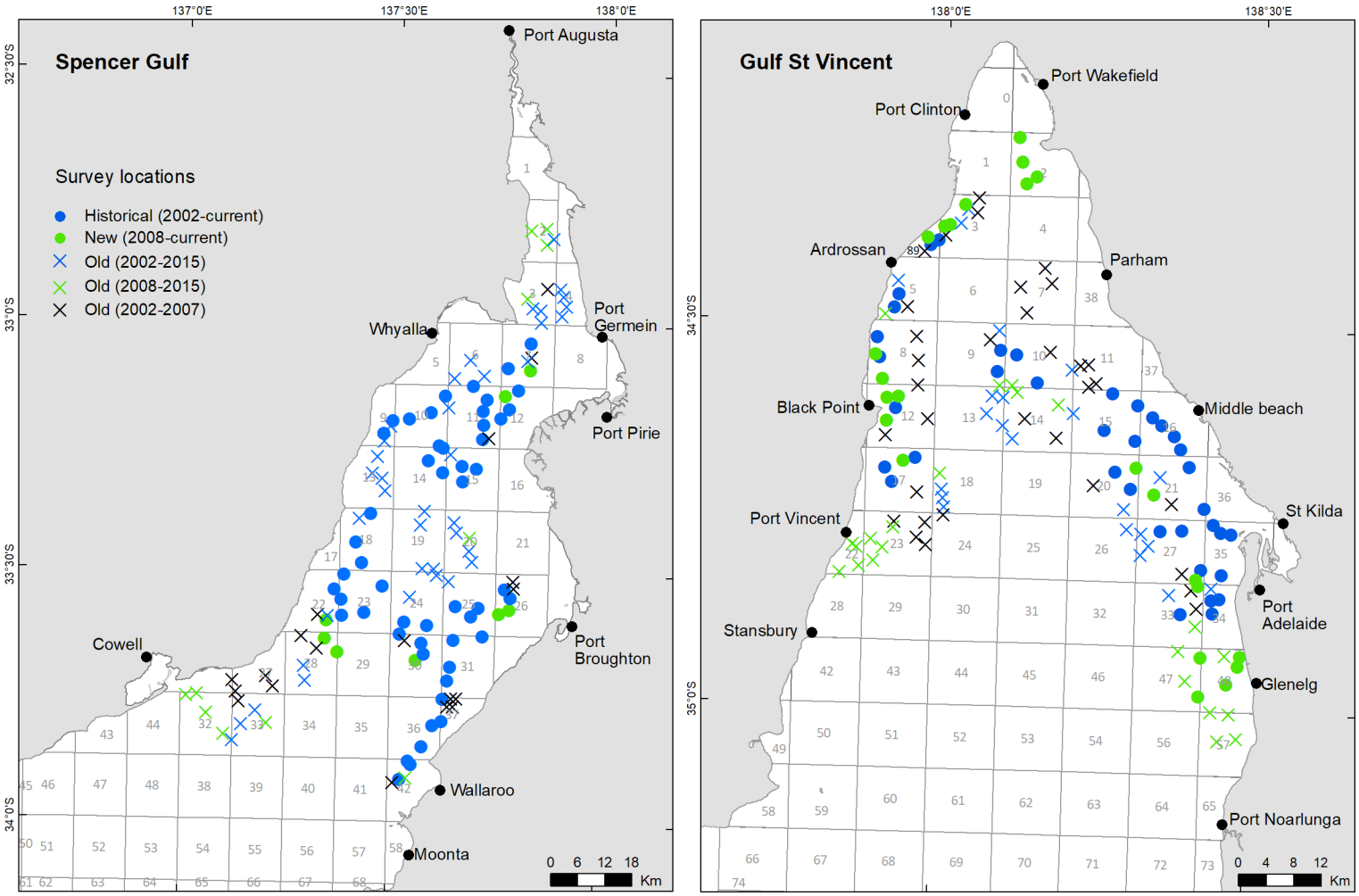

Figure 2.1 Commercial fishing blocks (grid) and fishery-independent survey (FIS) locations in the Spencer Gulf and Gulf St Vincent zones of the Blue Crab Fishery. Circles represent the 60 sites chosen for the harvest strategy (historical sampled since 2003 in blue, new sampled since 2008 in green), crosses represent sites no longer sampled (blue sites sampled from 2002-15, green sites sampled from 2008-15 and black sites sampled from 2003-07) following survey design changes. Note- not all sites were sampled during the 2002 surveys.

2.2. Commercial catch and effort statistics

Commercial catch and effort data are recorded in SARDI logbooks by licensed fishers operating in the SG and GSV pot fishing zones, and in the MSF as part of their licence conditions. In addition to catch and effort data, daily records of fishing block, depth, and the number and sex of Blue Crabs caught are recorded by pot fishers. Additional information on targeted effort using potlifts (by the BCF) is recorded on second potlifts, when pot fishers have lifted and reset their gear on the same day. Under these circumstances, soak time is generally 18 to 20 hours for the first potlift, and 4 to 6 hours for the second potlift.

State-wide catch estimates are presented as combined total catch for each region (i.e. GSV, SG and WC) and total recreational catch. Targeted effort data are expressed in boat days (days fished per licence) and total number of potlifts (first or second lift). Annual estimates of targeted nominal commercial CPUE are expressed as the sum of the annual catch divided by the total number of boat days (kg.boat day^{-1}) and the daily catch divided by the daily number of potlifts by licence (kg.potlift^{-1}). The spatial distribution of the annual catch was examined to determine the number of blocks fished and the magnitude of catches within those blocks. When more than one block was reported per day, catch and effort were equally divided between the blocks reported.

2.3. Recreational catch and effort statistics

Quantifying the recreational sector's contribution to the State's total catch is important in determining the overall status of fish stocks and informing resource allocation issues. There have been four extensive recreational fishing surveys carried out in South Australia over the past 20 years. The first was a 'creel survey' that was undertaken throughout 1994 to 1996 (McGlennon and Kinloch 1997). State-wide telephone/diary surveys were undertaken in 2000/01 (Henry and Lyle 2003), 2007/08 (Jones 2009) and 2013/14 (Giri and Hall 2015). Of these four surveys, only the results from the most recent three surveys can be reliably compared, as their data were collected using similar methods.

2.4. Quality assurance of data

All logbook data are entered and validated according to the quality assurance protocols identified for the BCF (Vainickis 2010). The data are stored in an Oracle database, backed up daily, and with access restricted to SARDI Information Systems staff. All FIS data are entered into Excel spreadsheets. Accuracy of data entry is verified by checking a subset (20%) of the data against the original data sheets. Once validated, data are stored on a network drive with restricted access to SARDI staff involved in research projects undertaken by the Crustaceans Sub-program.

3. RESULTS

3.1. State-wide

3.1.1. Commercial

The State-wide commercial catch of Blue Crabs increased from 87 t in 1983/84 to 651 t in 1995/96 (Figure 3.1). During 1983/84 and 1984/85 most catch was harvested from the WC region and, thereafter, most was harvested from SG. Annual TACC limits were introduced in the gulfs in 1996/97, resulting in a 29% reduction in State-wide catch. From 1996/97, State-wide catch generally increased, peaking at 662 t in 2007/08. Since this period, catch has been relatively stable in the fishery. In 2018/19, the State-wide catch was 659 t which was just above the previous 10-year average (629 ± 11 t [SE]).

3.1.2. Recreational

In the most recent survey, Giri and Hall (2015) reported that there were 277,027 recreational fishers in South Australia and Blue Crabs were among the most commonly caught species during 2013/14. Estimates of recreational harvest have ranged from 390 t between May 2000 and April 2001 (Henry and Lyle, 2003), 283 t between November 2007 and October 2008 (Jones, 2009), and 376 t between December 2013 and November 2014 (Giri and Hall, 2015). In addition, McGlennon and Kinloch (1997) estimated an annual recreational catch of 161 t, of which 116 t were taken in GSV and 45 t in SG.

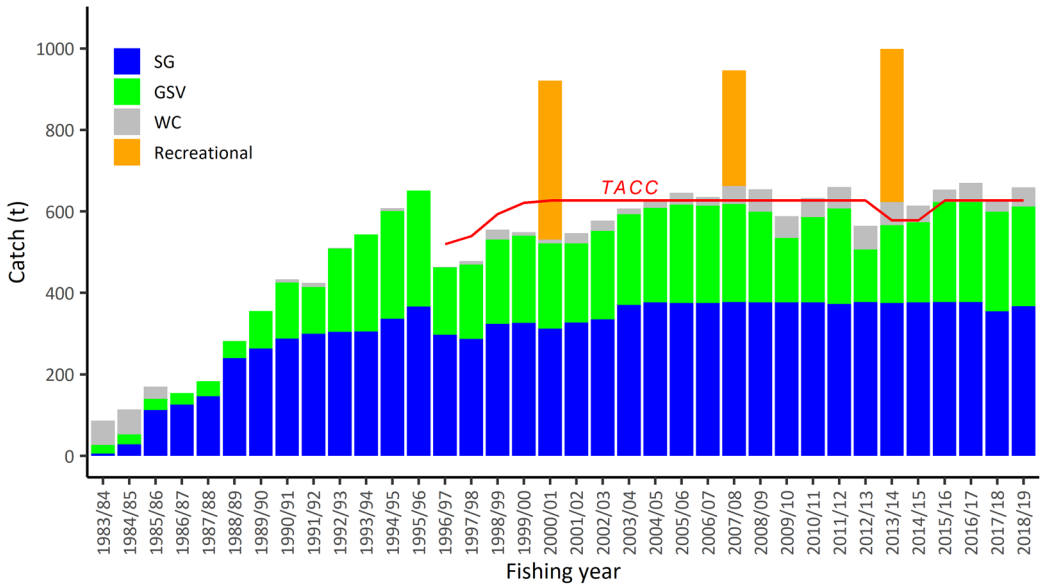

Figure 3.1 Commercial catch (t) of Blue Crabs from 1983/84 to 2018/19 in Spencer Gulf (SG); Gulf St Vincent (GSV) and from the West Coast (WC). Values for recreational catch (t) were provided in 2000/01, 2007/08 and 2013/14.

3.2. Spencer Gulf

3.2.1. Catch

Spencer Gulf has been the most productive zone of the BCF in terms of total annual catch since 1984/85. The highest recorded annual commercial catch was 378 t in 2007/08 (Figure 3.2a). Following the introduction of annual TACC setting, a 22% reduction in catch occurred from 1995/96 (367 t) to 1997/98 (287 t). From 2003/04 to 2016/17, >99% of the TACC was taken and in 2017/18, 94% of the TACC was taken. In 2018/19, the catch was 371 t reflecting 97% of the annual TACC.

3.2.2. Effort

Annual targeted effort in the SG zone increased from 90 boat days in 1983/84 to 1,201 boat days in 1985/86 and remained relatively stable until 2007/08 (mean: 1,184 ± 23 [SE] boat days, Figure 3.2b). Effort decreased from 1,050 boat days in 2007/08 to 895 boat days in 2008/09 and has remained relatively stable since (mean: 741 ± 20 [SE] boat days). In 2018/19, 703 boat days were fished, this was a 4% increase compared to 2017/18 (674 boat days), and was below the previous 10-year mean (744 ± 22 [SE] boat days).

From 1997/98 to 2007/08, the number of potlifts increased from 102, 039 to the historical maximum of 160, 555 potlifts (Figure 3.2c). A large reduction in effort was recorded between 2007/08 and 2011/12, with a historical low of 84,756 potlifts recorded in 2011/12. From 2011/12 to 2018/19, the total number of potlifts per year was relatively stable (mean: 96,448 ± 2,681 [SE]). In 2018/19, 96,084 potlifts were recorded and this was the fourth lowest on record. The number of second potlifts increased from 5,718 in 1997/98 to a peak of 60,398 in 2008/09. The number of second potlifts decreased to 8,983 in 2010/12 and remained relatively stable until 2015/16 (mean: 9,779 ± 731 [SE]). No second potlifts were recorded during 2016/17 or 2017/18, with just 135 recorded in 2018/19.

3.2.3. CPUE

Commercial CPUE increased from 30 kg.boat day^{-1} in 1983/84 to 279 kg.boat day^{-1} in 1995/96 (Figure 3.2d). Following the introduction of annual TACC setting in 1996/97, CPUE continued to increase, peaking at 576 kg.boat day^{-1} in 2010/11. From 2011/12 to 2018/19, CPUE has remained relatively stable (mean: 518 ± 9 [SE] kg.boat day^{-1}). In 2018/19 CPUE was 528 kg.boat day^{-1}, which was the fifth highest on record.

Daily potlift CPUE was relatively stable from 1997/98 to 2009/10 (range: 2.4–3.3 kg.potlift^{-1}) before increasing to 4.4 ± 0.1 (SE) kg.potlift^{-1} in 2011/12 (Figure 3.2e). Since 2011/12, CPUE has remained relatively stable (range: 3.5–4.4 kg.potlift^{-1}). In 2018/19, CPUE was 3.9 ± 0.1

(SE) kg.potlift^{-1}, which represented a 5% decrease from 2017/18 (4.1 ± 0.1 [SE] kg.potlift^{-1}) but was the fourth highest on record.

3.2.4. Spatial distribution of commercial catch

The spatial distribution of catch has been variable in Spencer Gulf during the past 20 seasons (Figure 3.3). The number of blocks fished increased from 17 in 1997/98 to a peak of 40 in 2007/08. Thereafter, the number of blocks fished fluctuated, ranging from 39 blocks in 2013/14 down to 23 blocks in 2017/18 and this was the lowest recorded since 2000/01 (20 blocks). In 2018/19, 29 blocks were fished. While there is variation in catch distribution among years, generally no more than 20% of the total annual catch was harvested from any one block.

High catches (≥30 t per block) were observed in the upper part of the gulf (blocks 2, 3, 7 and 12), in most seasons (Figure 3.4). Peaks were observed in Block 3 during 2002/03, 2005/06, 2010/11 and 2018/19 (>60t). The area adjacent to Wallaroo (Block 41) also saw high catches in most years, exceeding 60 t in 2009/10 and 2012/13, while those from the Port Pirie area (block 12) peaked at 61 t in 2004/05 and 102 t during 2006/07. In 2018/19, high levels of catch were harvested in the upper gulf from Block 3 (71 t), adjacent to Cowell from Block 32 (49 t) and adjacent Wallaroo from Block 41 (42 t). Collectively, these three blocks accounted for 44% of the 2018/19 catch.

3.2.5. Temporal distribution of commercial catch

Blue Crabs are generally harvested throughout the year except in seasonal closures during December (prior to 2004/05) and January (except in 2016/17 when temporary summer fishing trials were introduced). From 1997/98 to 2004/05, catch was relatively evenly spread throughout the year, with peaks generally occurring in September, March or April (Figure 3.4). From 2005/06 onwards, an increased proportion of catch was generally harvested early in the season (i.e. from July to November). During 2018/19, the largest proportion of the catch was harvested during July through October (equivalent to 61% of the total annual catch).

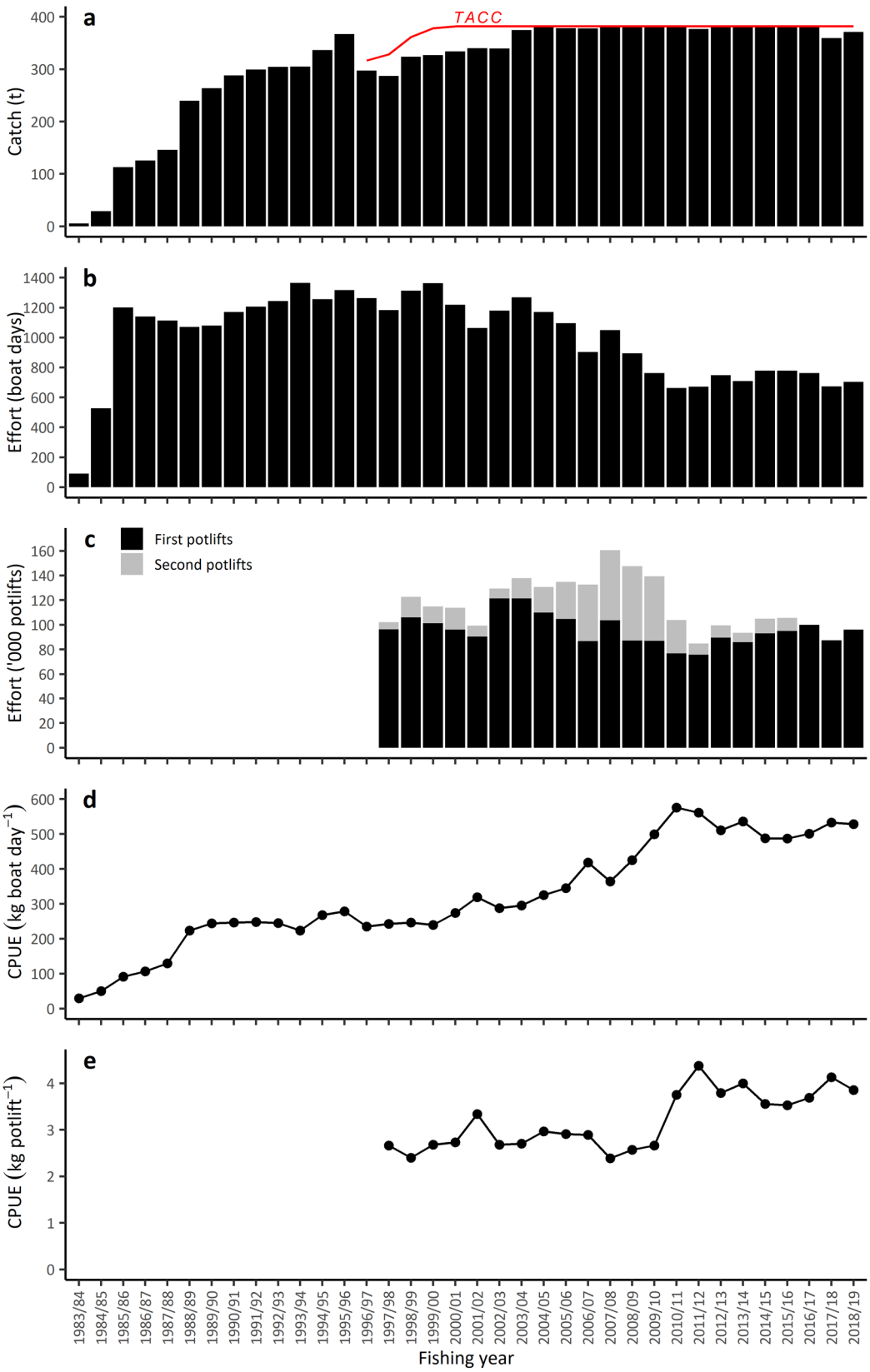

Figure 3.2 Fishery-dependent outputs for the Spencer Gulf zone of the Blue Crab Fishery. (a) Trends in total catch (t) including total allowable commercial catch (TACC) limit; (b) targeted effort (boat days); (c) total effort from first and second potlifts by the BCF ('000 potlifts); (d) catch per unit effort by day (CPUE, kg.boat.day^{-1}), and (e) CPUE by potlift (kg.potlift^{-1}).

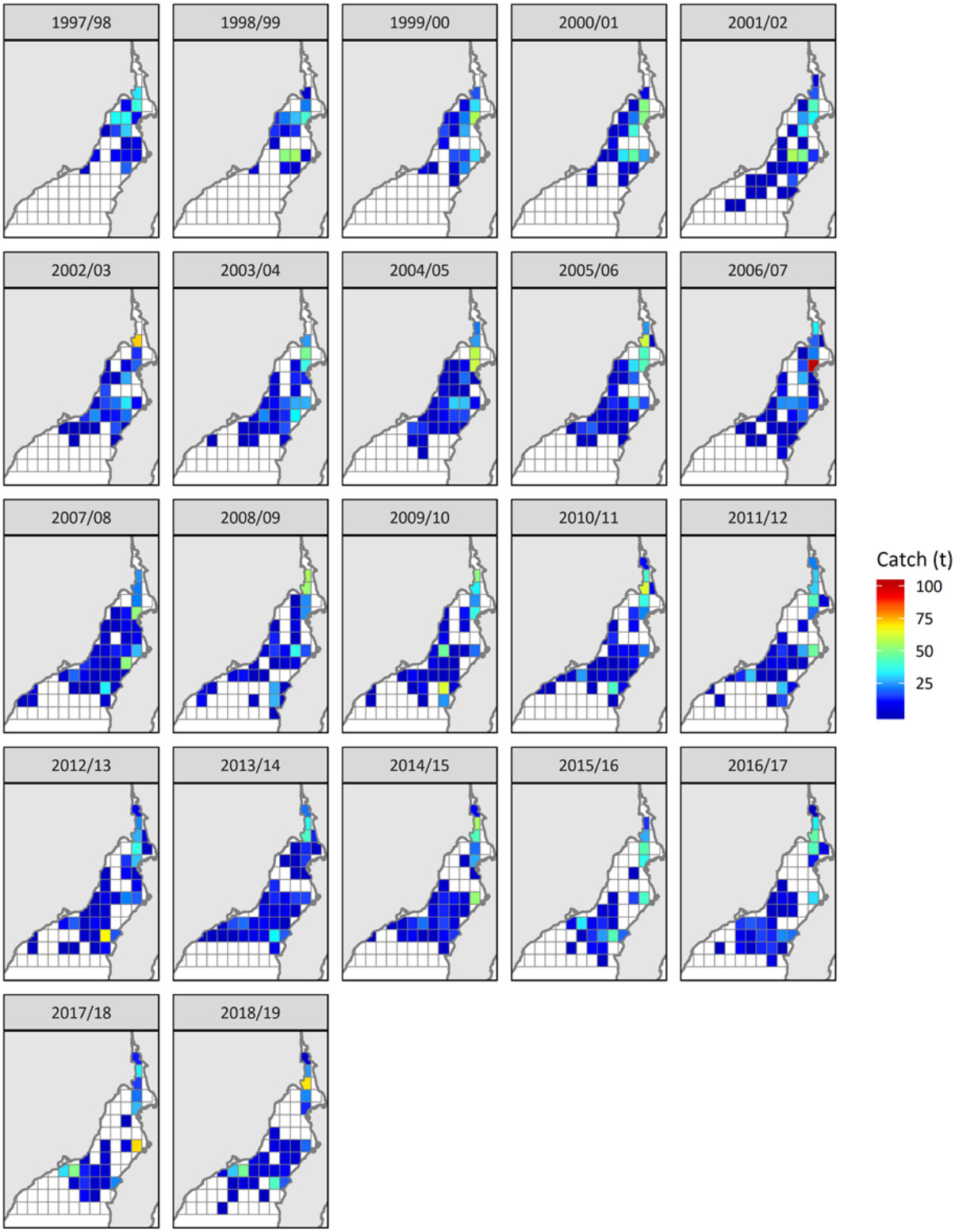

Figure 3.3 Commercial catch (t) reported by block for the Spencer Gulf Zone of the Blue Crab Fishery pot fishing sector from 1997/98 to 2018/19.

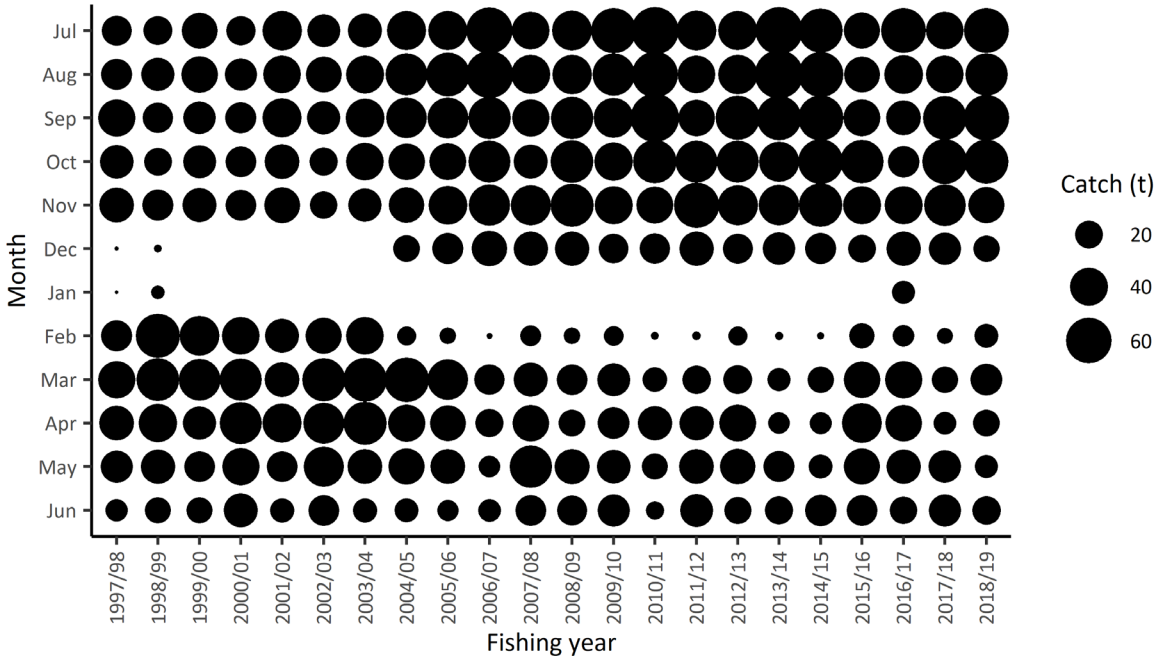

Figure 3.4 Monthly distribution of annual harvest (t) from the Spencer Gulf zone of the Blue Crab Fishery pot fishing sector during 1997/98 to 2018/19. Note: bubble area is proportional to monthly harvest.

3.2.6. Fishery-independent survey CPUE

The June/July CPUE of legal-size crabs increased at historical sites from 2002–2006 (range: 1.4 ± [SE] 0.1 to 2.6 ± [SE] 0.1 kg.potlift^{-1}; Figure 3.5a). From 2008, the June/July CPUE of legal-size crabs at historical sites followed a similar trend to locations selected under the harvest strategy. At harvest strategy sites, the June/July CPUE of legal-size crabs was relatively high from 2008–2014 (range: 2.2 ± [SE] 0.1 to 3.0 ± [SE] 0.1 kg.potlift^{-1}) and in 2017 (3.1 ± [SE] 0.1 kg.potlift^{-1}), while lower levels were observed in 2016 (2.0 ± [SE] 0.1 kg.potlift^{-1}) and 2018 (1.9 ± [SE] 0.1 kg.potlift^{-1}). No June/July survey was conducted in 2019. The March/April CPUE of legal-size crabs followed a similar trend to June/July from 2016–2018. The March/April CPUE of legal-size crabs increased 104% from 2.6 ± [SE] 0.1 kg.potlift^{-1} in April 2018 to 5.3 ± [SE] 0.1 kg.potlift^{-1} in March 2019; this was the highest value on record.

The June/July CPUE of pre-recruits has fluctuated since 2002 (Figure 3.5b). From 2002 to 2006, the June/July CPUE of pre-recruits at historical sites generally declined (range: 0.3 ± [SE] 0.0 to 1.0 ± [SE] 0.1 kg.potlift^{-1}). A 400% increase in the June/July CPUE of pre-recruits was observed at historical sites from 2006 (0.3 ± [SE] 0.0 kg.potlift^{-1}) to 2007 (1.5 ± [SE] 0.1 kg.potlift^{-1}). Since 2008, the June/July CPUE of pre-recruits at historical sites followed a similar trend to locations selected under the harvest strategy. The June/July CPUE of pre-recruits at harvest strategy sites remained relatively high during 2008 (1.2 ± [SE] 0.0 kg.potlift^{-1}), before

declining to 0.6 ± (SE) 0.0 kg.potlift^{-1} in 2009. From 2009 onwards, the June/July CPUE of pre-recruits generally increased peaking at 1.9 ± (SE) 0.1 kg.potlift^{-1} in 2017. In 2018, the June/July CPUE of pre-recruits decreased by 32% to 1.3 ± (SE) 0.1 kg.potlift^{-1} and was the sixth highest on record. No June/July survey was conducted in 2019. The March/April CPUE of pre-recruit crabs followed a decreasing trend from 2016–2019. The CPUE of pre-recruit crabs was 1.4 ± (SE) 0.1 kg.potlift^{-1} in March 2019, a 7% decrease compared to April 2018 (1.5 ± [SE] 0.1 kg.potlift^{-1}).

Spatial density plots indicate that blue crabs were broadly distributed throughout FIS sites sampled in March/April in SG during most years (Figure 3.6). The relative density of pre-recruit crabs declined from 2016 to 2019 in most blocks. High densities of pre-recruits were observed adjacent to Port Pirie (Blocks 11 and 12) and off the Western coastline (Block 18) in 2016 and 2017. In 2018 and 2019, pre-recruit density was highest adjacent to Port Broughton (Block 26). Legal-size crabs were generally concentrated in the northern SG, near Port Pirie and in the central gulf near Port Broughton. Lower legal-size densities were observed in 2016 and 2018, compared to 2017 and 2019. In 2017, high densities of legal-size crabs were observed adjacent to Port Broughton (Blocks 25, 30 and 31). In 2019, high legal-size densities were again observed adjacent to Port Broughton (Block 24, 30 and 36) and near Port Pirie (Block 7 and 12).

Sex-specific length-frequency data indicate that a high proportion of male crabs (>83%) were captured from March/April 2016–2019 (Figure 3.7). Females made up a low proportion (<17%) of the catch in all years. In 2016, 44% of crabs captured were legal-size and a large number of undersize male crabs were observed (mode: 105–109 mm). In 2016, female crabs were also mostly undersize (mode: 105–109 mm). In 2017, 58% of crabs captured were legal-size and legal-size male crabs were particularly abundant (mode: 115-119 mm). Female crabs were again mostly undersize during 2017 (mode: 105–109 mm). A similar trend was observed during 2018, when large numbers of legal-size males (mode: 110–114 mm) were recorded. In 2018, female crabs were again relatively small (mode: 105–109 mm). In 2019, 96% of crabs were legal-size males (mode: 115–119 mm) and females were generally close to legal-size (mode: 110–114 mm).

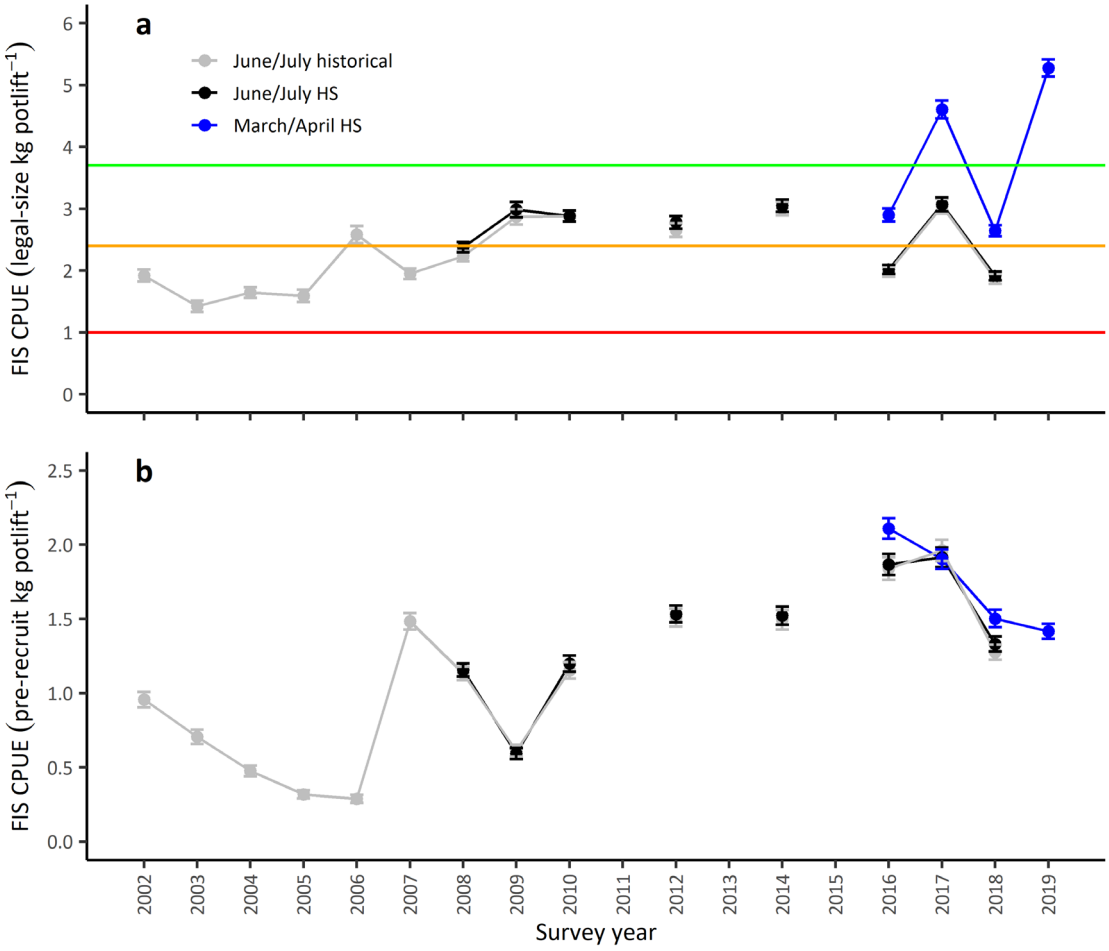

Figure 3.5 Key fishery-independent outputs used to assess the status of the Spencer Gulf zone of the Blue Crab Fishery (BCF). Fishery-independent (FIS) catch per unit effort (CPUE) by weight of (a) legal-size crabs (kg.potlift^{-1}), and (b) pre-recruit crabs (kg.potlift^{-1}). Historical sites refer to the 52 sites which have not changed since 2003 (excludes new sites) and Harvest Strategy (HS) sites refer to the subset of 60 sites sampled since 2008 (includes new sites). Green, yellow and red lines represent the target, trigger and limit reference points for March/April identified in the Draft Harvest Strategy (see Table 1.1). Error bars, standard error. Note. June/July surveys were not conducted in 2011, 2013, 2015 or 2019

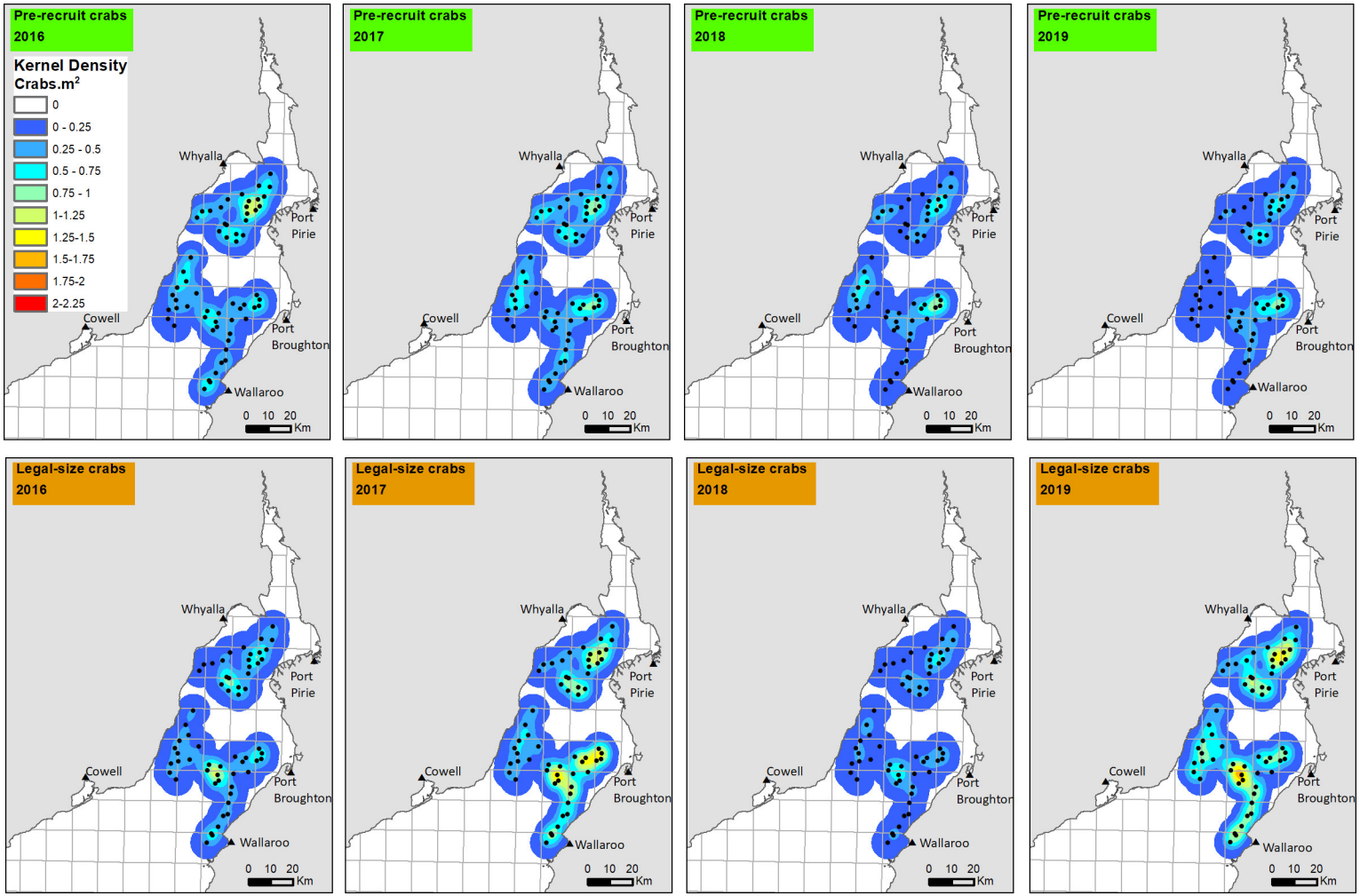

Figure 3.6 Relative density (crabs per square metre) of pre-recruit and legal-size crabs from March/April fishery-independent surveys (FIS) in Spencer Gulf. Sampling locations denoted by ●

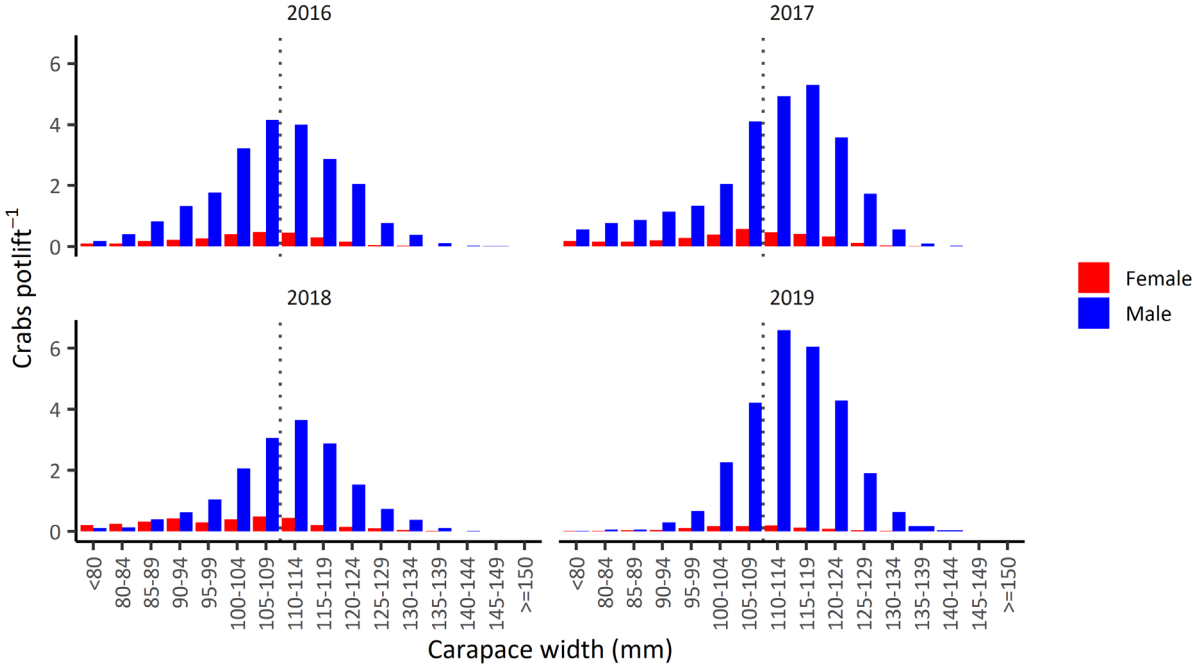

Figure 3.7 Length frequency distributions of male and female Blue Crabs from March/April fishery-independent surveys in Spencer Gulf sampled at 60 sites selected under the harvest strategy from 2016–2019. Minimum size limit 110 mm carapace width, CW (---).

3.3. Gulf St Vincent

3.3.1. Catch

GSV has produced >100 t of Blue Crabs per season since 1990/91. The highest recorded commercial catch was 285 t in 1995/96 and the lowest catch was 22 t in 1983/84 during the inception of the fishery (Figure 3.8a). Following the introduction of annual TACC setting in 1996/97, catch gradually increased from 165 t to 241 t in 2005/06—the latter comprising 98% of the annual TACC (245.1 t). Thereafter, catch fluctuated, reaching a low of 129 t in 2012/13 when commercial catch was voluntarily reduced by almost half. The GSV component of the TACC was subsequently reduced by 20% to 196 t in 2013/14 and remained at 196 t in 2014/15. In 2014/15, the entire annual TACC for the GSV (196 t) was harvested for the first time. In 2015/16, the GSV component of the annual TACC was increased to 245 t and since then has been fully harvested.

3.3.2. Effort

Prior to the introduction of annual TACC setting, there was a long-term trend of increasing targeted fishing effort in this zone, from 444 boat days in 1983/84 to 2,114 boat days in 1995/96 (Figure 3.8b). After the introduction of annual TACC setting, effort was largely transferred to the pot fishing sector resulting in a 54% decline in effort to 964 boat days in 1996/97. Effort continued to decline from 1088 boat days in 1997/98 to a historical low of 315 boat days in 2012/13. From 2013/14 to 2018/19, Effort has been relatively stable (mean: 484 ± 23 boat days). In 2018/19 effort reduced to 457 boat days from 2017/18 (515 boat days) and was the eighth highest value on record.

The number of total potlifts increased from 49,452 in 1997/98 to a historical maximum of 75,508 in 2005/06 (Figure 3.8c). From 2006/07 to 2011/12, effort was relatively stable (mean: 69,082 ± 1,310 [SE] potlifts), before declining to a historical low of 47,677 in 2013/14. From 2014/15 to 2018/19, the total number of potlifts was relatively stable (mean: 62,588 ± 2,219 [SE]). Like boat days, the number of potlifts in 2018/19 (60,613) reduced from 2017/18 (69,028); and was below the previous 10-year mean (62,811 ± 2,369 [SE] potlifts). From 1997/89 to 2011/12 the number of second potlifts was variable ranging from 432 in 1998/99 to 13,367 in 2008/09. Between 2012/13 and 2017/18, the number of second potlifts were low (range: 0–139 potlifts). During 2018/19, second potflifts remained low, at 219.

3.3.3. CPUE

Commercial CPUE increased from 35 kg.boat day^{-1} in 1983/84 to 473 kg.boat day^{-1} in 2008/09 (Figure 3.8d). Thereafter, CPUE fluctuated ranging from 349 kg.boat day^{-1} in 2009/10 to 536

kg.boat day^{-1} in 2018/19. CPUE increased 13% from 474 kg.boatday^{-1} in 2017/18 to 536 kg.boatday^{-1} in 2018/19 and was the highest value on record.

Average potlift CPUE increased from 2.6 ± 0.0 (SE) kg.potlift^{-1} in 1997/98 to 3.3 ± 0.1 (SE) kg.potlift^{-1} in 2007/08 (Figure 3.8e). CPUE fluctuated from 2008/09 to 2012/13, with low values of 2.4 ± 0.0 (SE) kg.potlift^{-1} and 2.3 ± 0.0 (SE) kg.potlift^{-1} observed in 2009/10 and 2012/13, respectively. CPUE has been relatively stable since 2013/14 (range: 3.3–3.9 kg.potlift^{-1}). CPUE increased 11% from 3.5 ± 0.0 (SE) kg.potlift^{-1} in 2017/18 to 3.9 ± 0.1 (SE) kg.potlift^{-1} in 2018/19 and was the highest value recorded.

3.3.4. Spatial distribution of commercial catch

The spatial distribution of catch has been variable in GSV during the past 20 seasons (Figure 3.9). The number of blocks fished generally increased from 11 blocks in 1998/99 to 24 blocks in 2008/09. Since then, the number of blocks fished has remained relatively stable (range: 19 to 28 blocks), with 23 blocks fished in 2018/19. While there is variation in catch distribution among years, generally no more than 40% of the total annual catch is harvested from any one block.

In most seasons, the highest levels of catch were harvested from blocks adjacent to the Adelaide Metropolitan coastline (Figure 3.10). This trend was driven by relatively high catches (> 20 t) from Blocks 21, 27 and 33, with peak catches (> 60 t per block) occurring from 2002/03–2006/07. From 2006/07–2011/12, relatively high catches were observed along the western coastline, particularly Block 17 (23–32 t). During 2018/19, the largest proportion of catch was reported from the metropolitan coastline, particularly Block 33 (30 t), 27 (29 t) and 48 (26 t), and the western coastline from Block 23 (30 t) and 28 (25 t).

3.3.5. Temporal distribution of commercial catch

Blue Crabs are generally harvested throughout the year except during seasonal closures (i.e. 1 November to 15 January). In GSV, no catch was taken from July through December during 2013/14 due to a voluntary closure, and from 2015/16, a summer fishing trial was introduced (during the normal closure period). From 1997/98 to 2015/16, peak catches generally occurred during February and March (Figure 3.10). During 2016/17 and 2017/18, peak catches shifted to July and September, respectively. This increase was offset by a corresponding reduction in harvests during February and March. During 2018/19, peak catches occurred during February and March, with approximately 27% of catch harvested during this period.

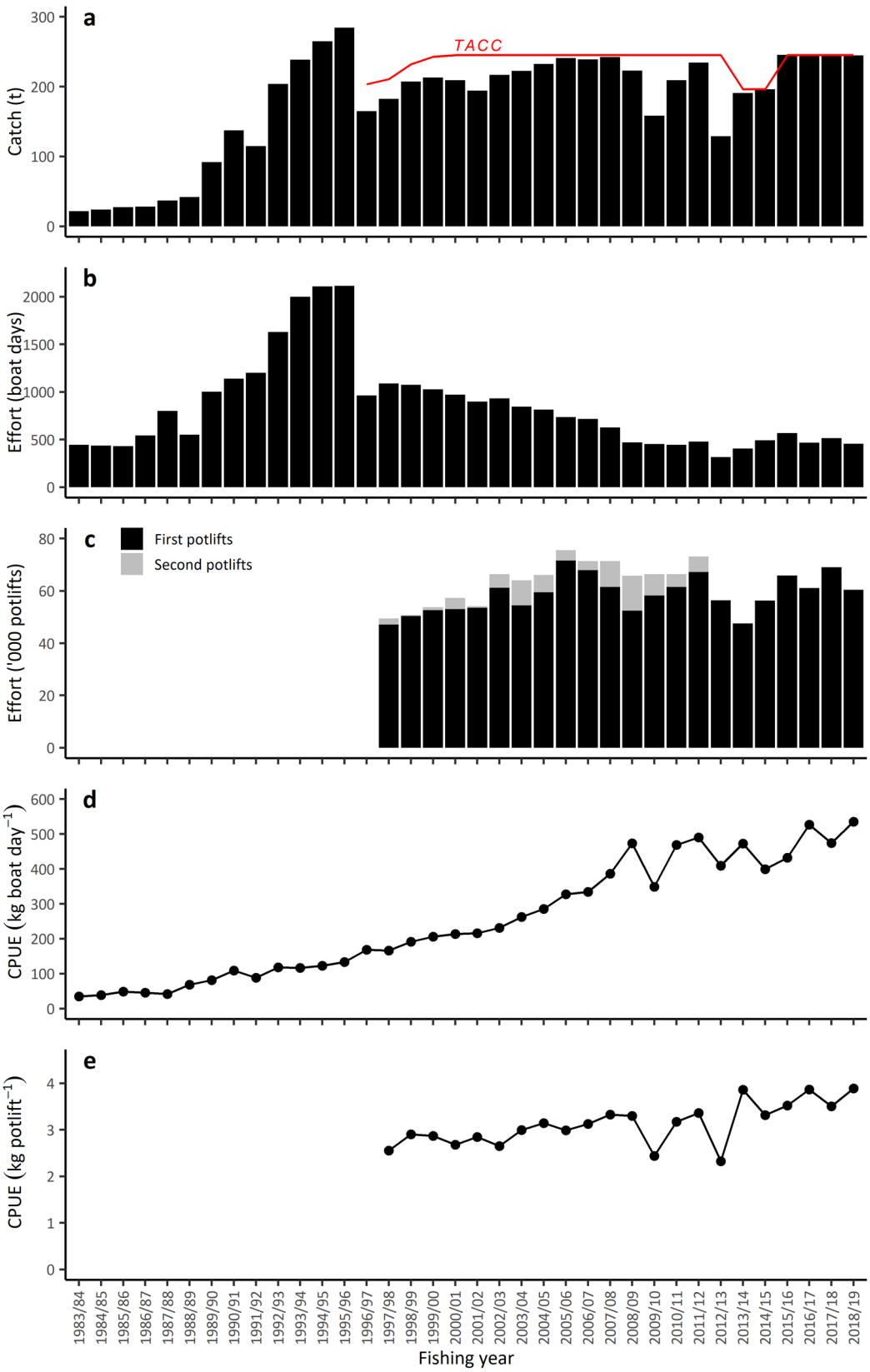

Figure 3.8 Fishery-dependent outputs for the Gulf St Vincent zone of the Blue Crab Fishery; (a) trends in total catch (t) including total allowable commercial catch (TACC) limit, (b) targeted effort (boat days), (c) total effort from first and second potlifts by the BCF, (d) catch per unit effort by day (CPUE, kg.boat.day^{-1}), and (e) CPUE by potlift (kg.potlift^{-1}).

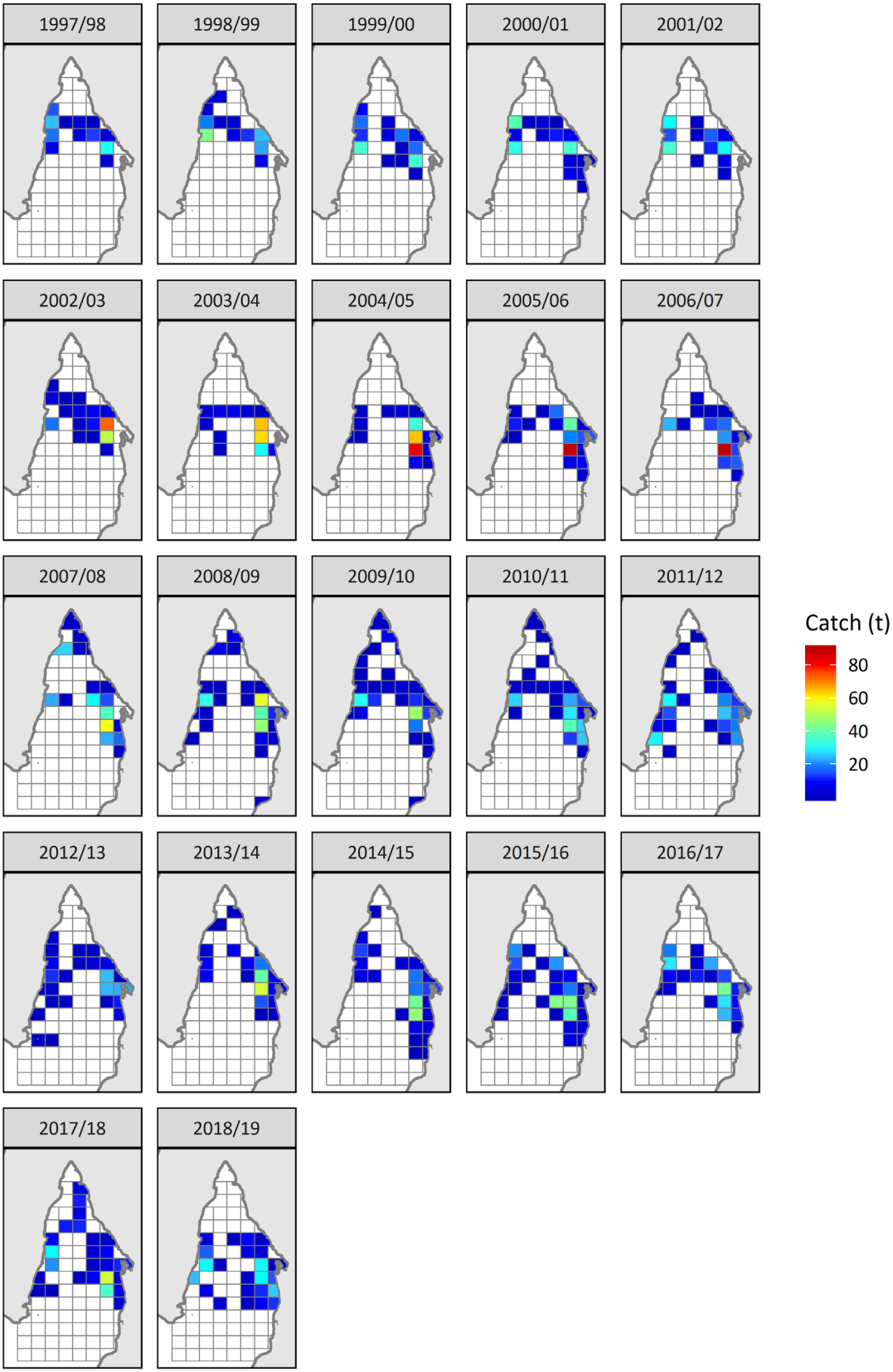

Figure 3.9 Commercial catch reported by block for the Gulf St Vincent Zone of the Blue Crab fishery pot fishing sector from 1997/98 to 2018/19.

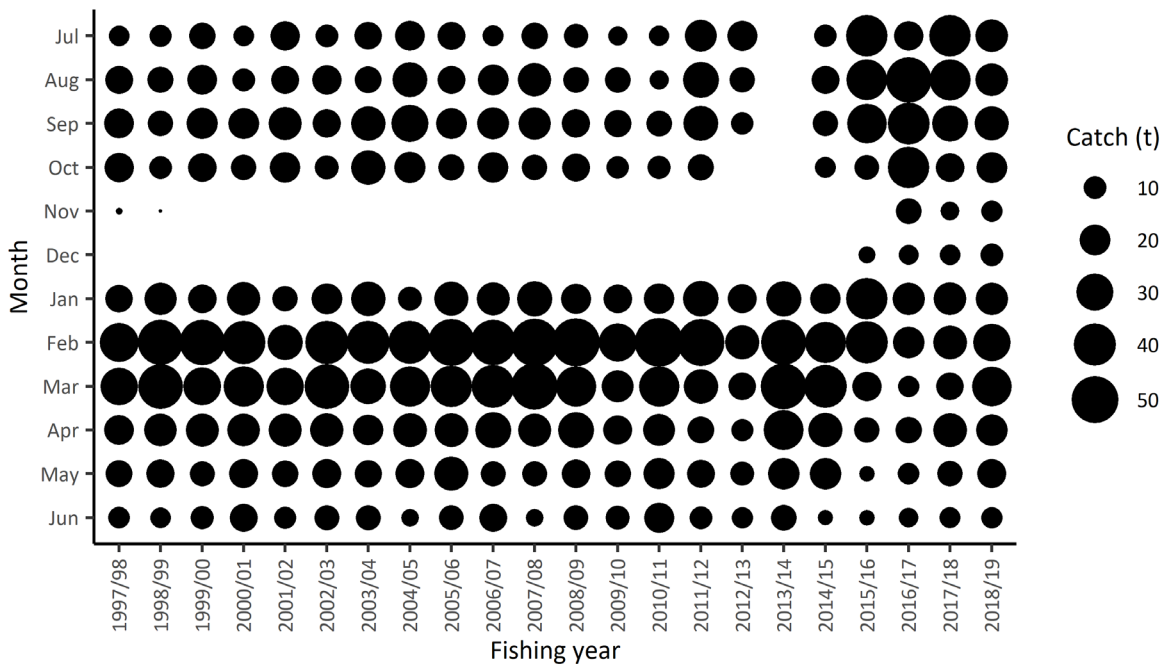

Figure 3.10 Monthly distribution of annual harvest from the Gulf St Vincent zone of the Blue Crab Fishery pot fishing sector during 1997/98 to 2018/19. Note: bubble area is proportional to monthly harvest.

3.3.6. Fishery-independent survey CPUE

From 2002 to 2007, annual estimates of legal-size June/July CPUE from the FIS were relatively low at historical sites (range: 0.6 ± 0.1 [SE] to 1.4 ± 0.1 [SE] kg.potlift^{-1}; Figure 3.11a). Subsequently, similar trends in June/July FIS CPUE have been observed at historical and harvest strategy sites (60 selected sampling locations). From 2008–2013, June/July CPUE of legal-size crabs declined, reaching historical lows of 0.5 ± 0.1 (SE) kg.potlift^{-1} in 2012 and 2013 at HS sites, and the lowest value on record in 2013 for historical sites. June/July CPUE of legal-size crabs then steadily increased, reaching a peak of 2.9 ± 0.1 (SE) kg.potlift^{-1} in 2016 and remaining high with a value of 2.8 ± 0.1 (SE) kg.potlift^{-1} in 2017. In 2018, June/July CPUE of legal-size crabs decreased 50% to 1.4 ± 0.1 (SE) kg.potlift^{-1}, but was the fourth highest on record.

From 2015 to 2016, legal-size CPUE increased in March/April, following a similar trend to June/July. From 2016 to 2017, the March/April CPUE followed a different trend to June/July. The March/April CPUE of legal-size crabs increased 63% from 2016 (3.2 ± 0.1 [SE] kg.potlift^{-1}) to 2017 (5.2 ± 0.2 [SE] kg.potlift^{-1}). No March/April survey data was available for 2018. During 2019, the March/April CPUE of legal-size crabs decreased by 8% to 4.8 ± 0.2 [SE] kg.potlift^{-1}; this was the second highest value on record.

The June/July CPUE of pre-recruits recorded by the FIS have fluctuated since 2002 (Figure 3.11b). High pre-recruit CPUE was recorded from historical sites in 2006 (1.6 ± 0.2 [SE] kg.potlift^{-1}). From 2008 onwards, the June/July CPUE of pre-recruit crabs fluctuated, with similar trends observed at historical and harvest strategy sites. Three further peaks in June/July pre-recruit CPUE were observed at harvest strategy sites in 2010, (1.1 ± 0.1 [SE] kg.potlift^{-1}), 2015 (1.2 ± 0.1 [SE] kg.potlift^{-1}), and 2017 (1.4 ± 0.1 [SE] kg.potlift^{-1}). The March/April CPUE of pre-recruit crabs followed a similar trend to June/July from 2015 to 2019, noting that no March/April survey data was available for 2018. The March/April CPUE of pre-recruit crabs decreased 89% from 2015 (0.9 ± 0.1 [SE] kg.potlift^{-1}) to 2016 (0.1 ± 0.0 [SE] kg.potlift^{-1}), before increasing 300% to 0.4 ± 0.0 (SE) kg.potlift^{-1}in 2017. During 2019, the March/April CPUE of pre-recruit crabs increased by 25% to 0.5 ± 0.0 (SE) kg.potlift^{-1}; this was the second highest value on record.

Density data obtained from March/April FIS conducted between 2015 and 2018 indicated that legal-size and pre-recruit crabs were widely distributed throughout GSV (Figure 3.12). Pre-recruit densities were highest in 2015, particularly North of Port Adelaide (Blocks 20 and 35); adjacent to Ardrossan (Block 89) and south of Ardrossan (Block 17). During 2016, 2017 and 2019, low densities of pre-recruits were observed throughout GSV, with only a small peak

North of Port Adelaide in 2017 (Block 35) and 2019 (Block 16 and 35). Legal-size densities were relatively low during 2015 and 2016, with the highest densities observed near Port Adelaide in 2015 (Block 16) and 2016 (Block 35). In 2017 and 2019, increased densities were observed adjacent to Ardrossan (Block 3 and 89), north of Port Adelaide (Block 15 and 16) and adjacent to Port Adelaide (Block 27). In 2019, high legal-size densities were observed off the Adelaide Metropolitan coastline (Blocks 33, 34 and 35).

Sex-specific length-frequency data indicate that a high proportion of male crabs (>91%) were captured from March/April 2015–2017 and 2019 (Figure 3.7). Females made up a low proportion (<9%) of the catch. In 2015, 62% of crabs captured were legal-size, and this was reflected by a high proportion of legal-size male crabs (mode: 120–124mm), while females were generally smaller (mode: 105–109 mm). In 2015, there was also a secondary peak in undersize males (105–109 mm). In 2016, 95% of crabs captured were legal-size. This was driven by a large proportion of large male crabs (mode: 120-124 mm), while female crabs were also relatively large (mode: 110–114 mm). In 2017, 86% of crabs were legal-size and a high proportion of large male crabs was observed (mode: 125–129 mm). The modal size of female crabs was also relatively large at 115–119 mm. In 2019, 87% of crabs captured were legal-size, with a large modal size of 115–119mm for male crabs. The modal size for females was also relatively large during 2019 at 110–114 mm.

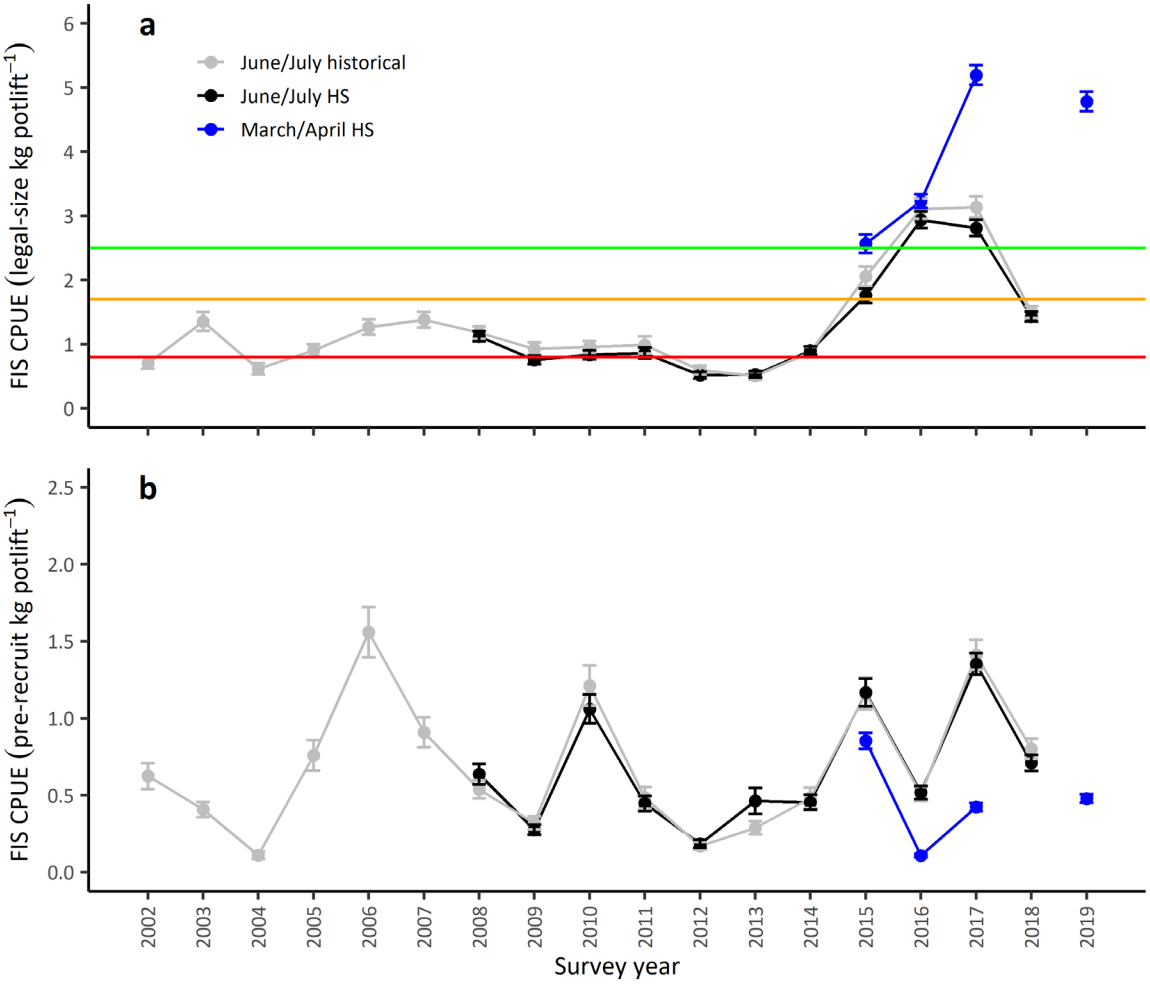

Figure 3.11 Key fishery-independent outputs used to assess the status of the Gulf St Vincent zone of the Blue Crab Fishery (BCF). Fishery-independent (FIS) catch per unit effort (CPUE) by weight of (a) legal-size crabs (kg.potlift^{-1}), and (b) weight of pre-recruit crabs (kg.potlift^{-1}). Historical sites refer to 37 sites which have not changed since 2003 (excludes new sites) and Harvest Strategy (HS) sites refer to the subset of 60 sites sampled since 2008 (includes new sites). Green, yellow and red lines represent the target, trigger and limit reference points for March/April identified in the draft harvest strategy, see Table 1.1. Error bars, standard error. Note: no survey was conducted in March/April 2018 or June/July 2019.

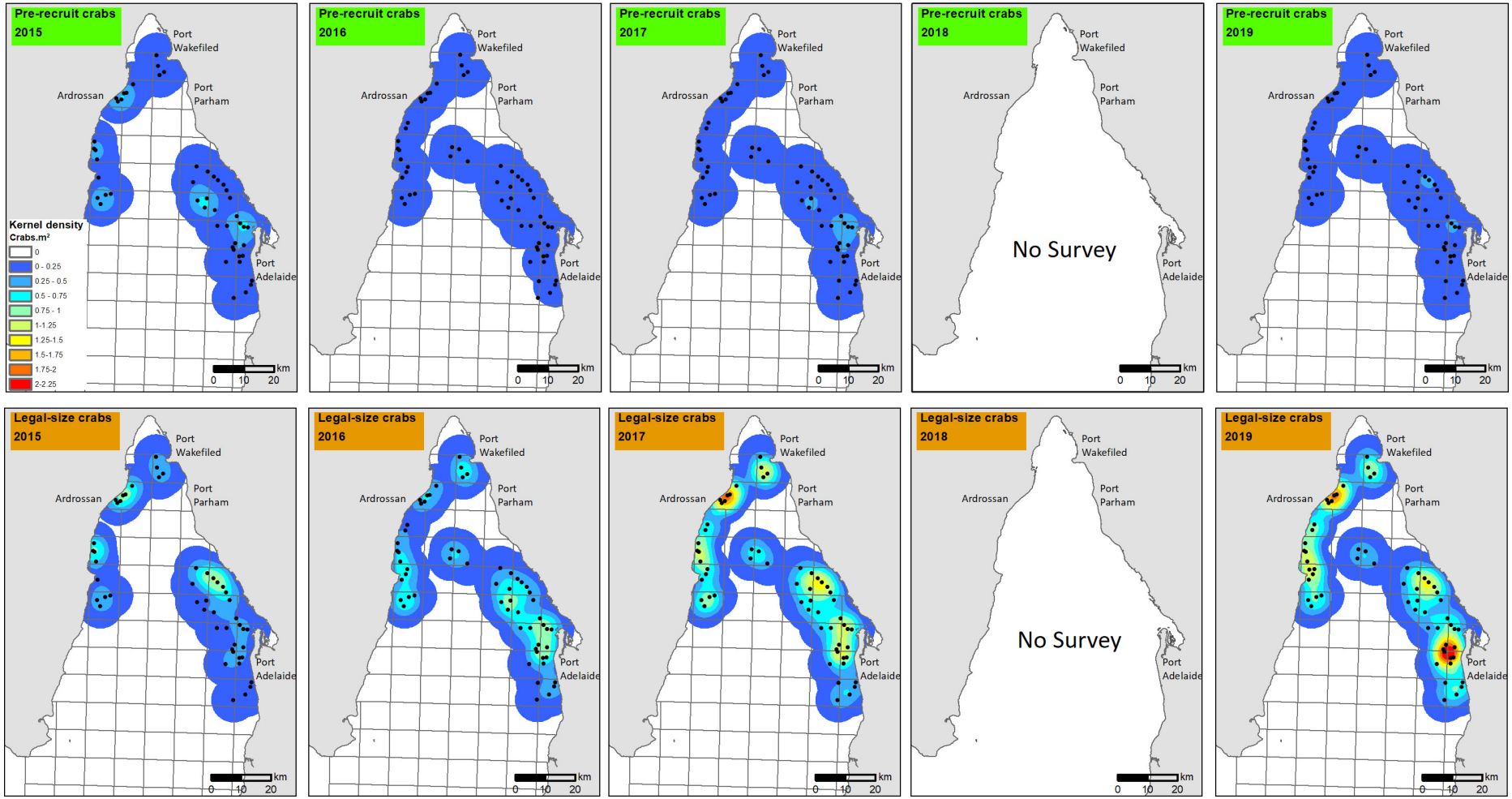

Figure 3.12 Relative density (crabs per square metre) of pre-recruit and legal-size crabs from March/April fishery-independent surveys (FIS) sampled in Gulf St Vincent. Sampling locations denoted by ●. Note: no survey was conducted in March/April 2018.

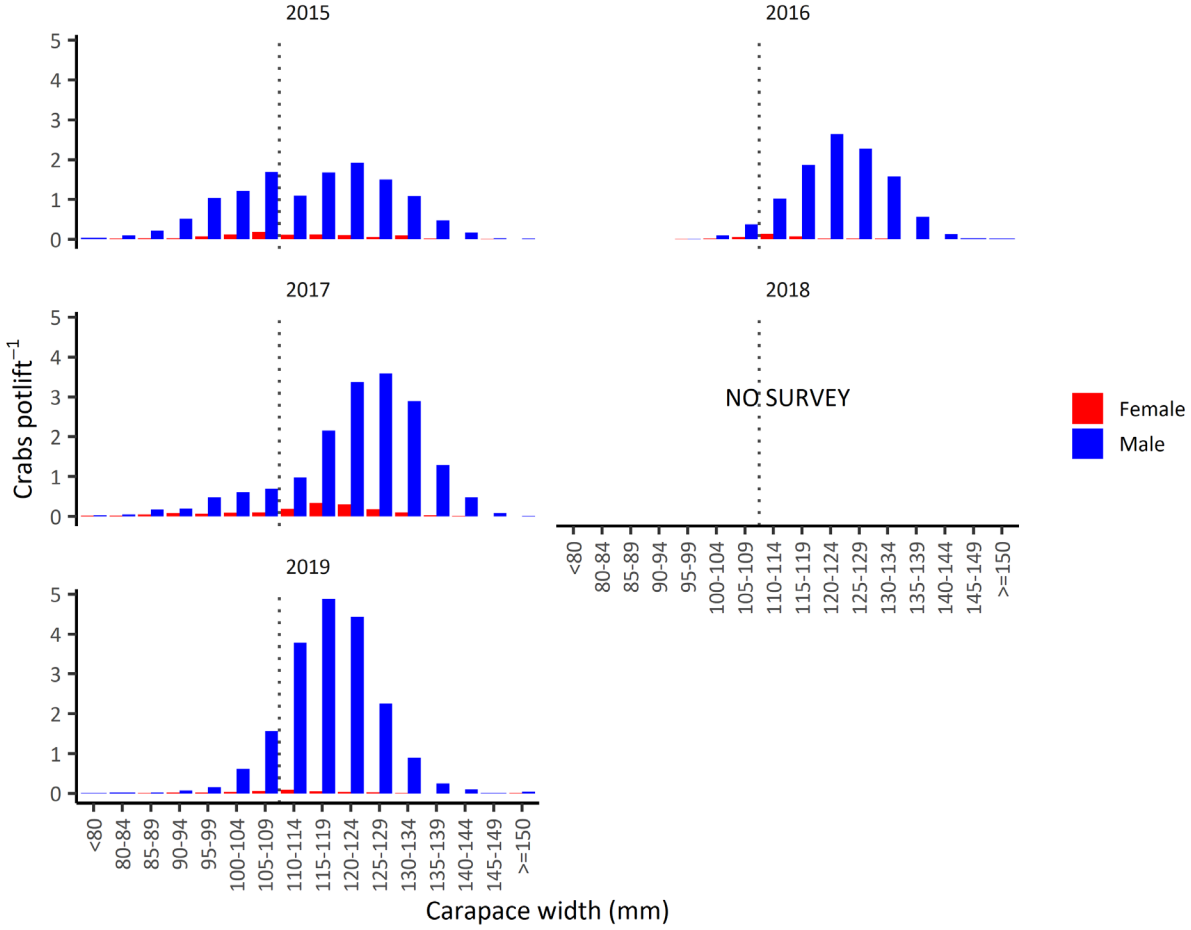

Figure 3.13 Length frequency distributions of male and female Blue Crabs from March/April fishery-independent surveys in Gulf St Vincent sampled at 60 sites selected under the harvest strategy from 2015–2019. Minimum size limit 110 mm carapace width, CW (---). Note: no survey was conducted in March/April 2018.

3.4. Fishery Performance

The CPUE of legal-size crabs measured during March/April FIS's is the primary PI under the Harvest Strategy in the Draft Management Plan (PIRSA 2019). In SG and GSV, the CPUE legal-size crabs was above the target RP in 2018/19 (Table 3.1).

Table 3.1 Summary of the performance of the Spencer Gulf (SG) and Gulf St Vincent (GSV) pot fishing zone for 2016/17–2018/19. The key biological performance indicators (PIs) under the Harvest Strategy in the Draft Management Plan are presented (PIRSA 2019).

Performance	**Zone**	**Reference Point**				**Season**		
		Limit	**Trigger**	**Target**		**2016/17**	**2017/18**	**2018/19**
March/April Legal-size CPUE (kg.potlift^{-1})	SG	1.0	2.4	3.7		4.6	2.6	5.3
	GSV	0.8	1.7	2.5		5.2	NA	4.8

4. DISCUSSION

4.1. Information sources used for assessment

The current Management Plan for the fishery provides the decision rules for classifying the status of the Blue Crab stock in SG and GSV (PIRSA 2018). It uses limit, trigger and target RPs defined for the primary PI relating to relative biomass. Under the Management Plan June/July 2018 FIS data were used to inform the stock status determination for the 2017/18 season and to inform TACC for the 2019/20 fishing season. This represented a time lag in data uptake of approximately 12 months for TACC setting.

The harvest strategy was recently reviewed and revised RPs and PIs were developed based on paired March/April and June/July surveys (PIRSA 2019). As three paired surveys were completed during March/April and June/July in both gulfs, June/July surveys were not undertaken during 2019. Instead, March/April surveys were completed to inform the 2018/19 stock status determination and inform TACC setting for the 2020/21 season approximately 3 months later. The PIs and RPs developed relative to March/April CPUE utilised in this report are outlined in the draft Management Plan and were released for public consultation in November 2019 (PIRSA 2019). As in the previous Management Plan (PIRSA 2018), the draft Management Plan (PIRSA 2019) outlines a modified traffic light method that is used to inform the current status of the resource. Green is within the target range (sustainable), yellow is within the trigger range (transitional) and red is below the limit (depleted).

4.1.1. Primary biological performance indicator

The primary biological PI to determine stock status and the annual TACC for the BCF is legal-size CPUE measured during the March/April FIS, which is used as an index of relative biomass and fishing mortality. Since 2002, a comprehensive FIS program has been conducted to contribute towards the assessment of the status of the Blue Crab stock in SG and GSV. The methods used to collect the data have remained relatively consistent (Beckmann and Hooper, 2017). While June/July surveys have been completed from 2002–2018, March/April surveys commenced in 2015 in GSV and 2016 in SG, providing four years of paired survey data to re-calibrate PIs and RPs relative to the CPUE observed during March/April.

4.1.2. Other biological performance indicators

Additional biological PIs specified in the draft Management Plan are CPUE of pre-recruits (kg.potlift^{-1}), which is measured during the March/April FIS and commercial CPUE (kg.potlift^{-1}) (PIRSA 2019). The FIS data are considered to provide the most reliable indices of relative abundance. This is because: 1) FIS include a standardised sampling design (with respect to locations, months and gear); 2) the difficulty in quantifying the effects of fisher experience, temporal and spatial shifts in catch and

effort, and improvements in catching efficiency (e.g. gear modification, vessel technology, selectivity of commercial pots) on commercial CPUE; and 3) the limited data (spatially and temporally) available from the voluntary pot-sampling program.

4.2. Stock status

4.2.1. Spencer Gulf

From 2011/12 to 2017/18, the SG zone of the BCF has been classified as 'sustainable'. The annual TACC was nearly fully harvested (≥ 98%) from 2003/04 to 2016/17. In 2017/18, 94% of the TACC was harvested, increasing to 97% in 2018/19. This was the equivalent to a 22 t and 10 t under-catch in 2017/18 and 2018/19, respectively. Overall, stock sustainability is reflected in annual commercial CPUE, which has remained relatively stable for at least the past ten seasons.

Trends in FIS data indicate that the CPUE of legal-size crabs has been above the trigger RP since 2016, when March/April surveys commenced. Since 2016, legal-size CPUE has fluctuated with high values observed during March/April 2017 and 2019. In March/April 2019, legal-size CPUE increased by 50% compared to 2018 and was the highest on record. March/April pre-recruit CPUE was similar between 2018 and 2019. While pre-recruit CPUE and has generally shown a declining trend since 2016, it remains above historically low levels observed during June/July from 2002–2006.

In SG, the 2018/19 legal-size CPUE was 5.3 ± 0.1 (SE) kg.potlift^{-1}. This was above the trigger RP (2.4 kg.potlift^{-1}) defined for this PI. As a result, the stock is classified as '**sustainable**'.

4.2.2. Gulf St Vincent

From 2013/14 to 2017/18, the GSV zone of the BCF has been classified as 'sustainable'. The annual TACC was fully harvested from 2014/15 to 2018/19. Overall, stock sustainability is reflected in annual commercial CPUE, which has generally increased since 2014/15.

Catch rates from the FIS have been above the trigger RP since 2015 when March/April surveys commenced. While March/April FIS data was not available during 2018, the 2019 legal-size CPUE was the second highest recorded since surveys commenced in 2015. Pre-recruit CPUE was the second highest recorded for March/April in 2018 and was comparable to March/April 2017 levels where June/July pre-recruit CPUE was amongst the highest value recorded.

In GSV, the 2018/19 legal-size CPUE was 4.8 ± 0.1 (SE) kg.potlift^{-1}. This was above the trigger RP (1.7 kg.potlift^{-1}) defined for this PI. As a result, the stock is classified as '**sustainable**'.

4.3. Future directions

During the recent harvest strategy review, legal-size CPUE from March/April and June/July surveys was examined using a simple linear regression to predict March/April CPUE based on the values observed during June/July. The linear equation was then used to convert existing June/July RPs to equivalent values for March/April and associated decision rules were developed for TACC setting. The key challenge to undertaking this analysis was that the short study period (3-4 years in each gulf) coincided with a period of relatively high biomass in both Gulfs. Therefore, limited data was available to inform the conversion of the trigger and limit RPs, as the study period did not coincide with CPUE values in this range. This is particularly relevant for GSV where June/July CPUE indicated declines in biomass in recent years, prompting changes to stock status and triggering TACC reductions.

Given the uncertainty around CPUE predictions outside of the range of observed values, future research may look to examine the long-term trends in commercial fishing data during March/April. This data is currently available from fishery logbooks, which provide long-term records of daily fishing activity. However, there are a number of factors (e.g. gear types, spatial and temporal patterns, vessel/fisher effects, and environmental factors) that can influence catch rate and are not related to stock abundance. Therefore, it would be desirable to attempt to standardise commercial CPUE. While this time series may be useful for historical comparisons, the low number of fishers in the BCF is likely to limit the stand-alone use of commercial CPUE as a reliable proxy for relative biomass.

The most reliable proxy for relative biomass for the BCF continues to be CPUE derived from FIS. Research pots (small-mesh and small-diameter) have been sampled alongside various commercial pot types (various mesh-sizes and diameters) since surveys commenced in 2002. The key advantage of the research pot-type is that CPUE is comparable through time, with no changes in pot efficiency. Research pots are also more efficient at catching pre-recruits, generally found in high abundances during June/July. This was reflected in the original Management Plan for the fishery, which utilised pre-recruit CPUE measured during June/July FIS as the primary PI. Under the revised Management Plan, the research pot-type could continue to provide comparable CPUE estimates during March/April. However, given that, legal-size CPUE is now the primary PI under the revised harvest strategy; the use of commercial pot-types can be considered as an alternative. This is because commercial pots are designed to be highly efficient at targeting legal-size crabs whilst maintaining lower mortality rates and reducing the level of bycatch. The challenge is that there is no standardised commercial pot type for this fishery, making it difficult to compare survey results between years. This could be addressed by attempting to standardise FIS CPUE to account for the influence of gear type and other factors that could influence catch rate. Importantly, a transition to using commercial pot-types would require the development of new RPs specific to the pot types to be used during March/April FIS.

Another consideration following the FIS transition to March/April is the data currently used to inform the length-weight relationship. This is important as FIS CPUE is calculated by measuring the carapace width of each individual crab captured during FIS and converting this to individual crab weight using a length-weight equation. The length-weight equation was developed based on a 2009 study conducted during surveys in June/July. Therefore, a further study is required to update the length-weight relationship relative to March/April across a range of size classes, sexes and geographic distributions. A majority of the crab samples could be collected from the March/April FIS, however, pre-recruit and female crabs are generally less abundant during March/April and some supplementary sampling away from the main fishing grounds may be required. As the condition of crabs is likely to vary spatially and temporally, the updated length weight relationship is likely to alter existing March/April CPUE values. As a result, the RPs in the harvest strategy will need to be updated specific to the March/April length-weight relationship.

Finally, the most recent recreational fishing survey was conducted during 2013/14. This indicated that Blue Crabs were among the most commonly caught species by South Australia's 277,027 recreational fishers (Giri and Hall 2015). Timely and accurate estimates of recreational catch and effort continue to be a major research gap when assessing stock status for the BCF.

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APPENDIX A: FISHERY INDEPENDENT SURVEYS

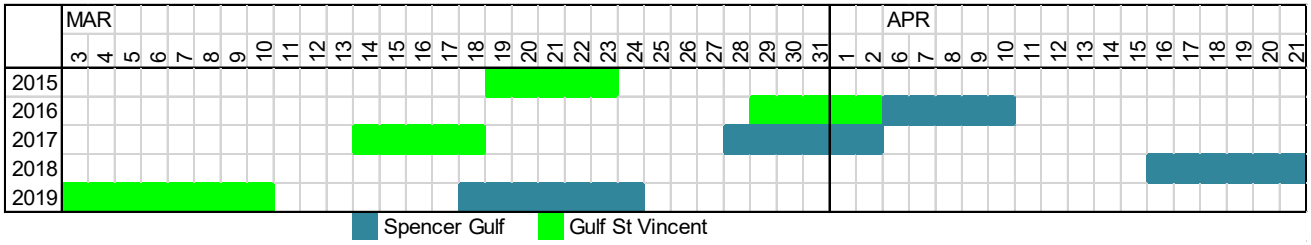

Figure A. 1 Fishery-independent survey (FIS) calendar for Spencer Gulf (SG) and Gulf St Vincent (GSV) during March and April from 2015 to 2019.

APPENDIX B: GEAR SELECTIVITY

B.1 Spencer Gulf

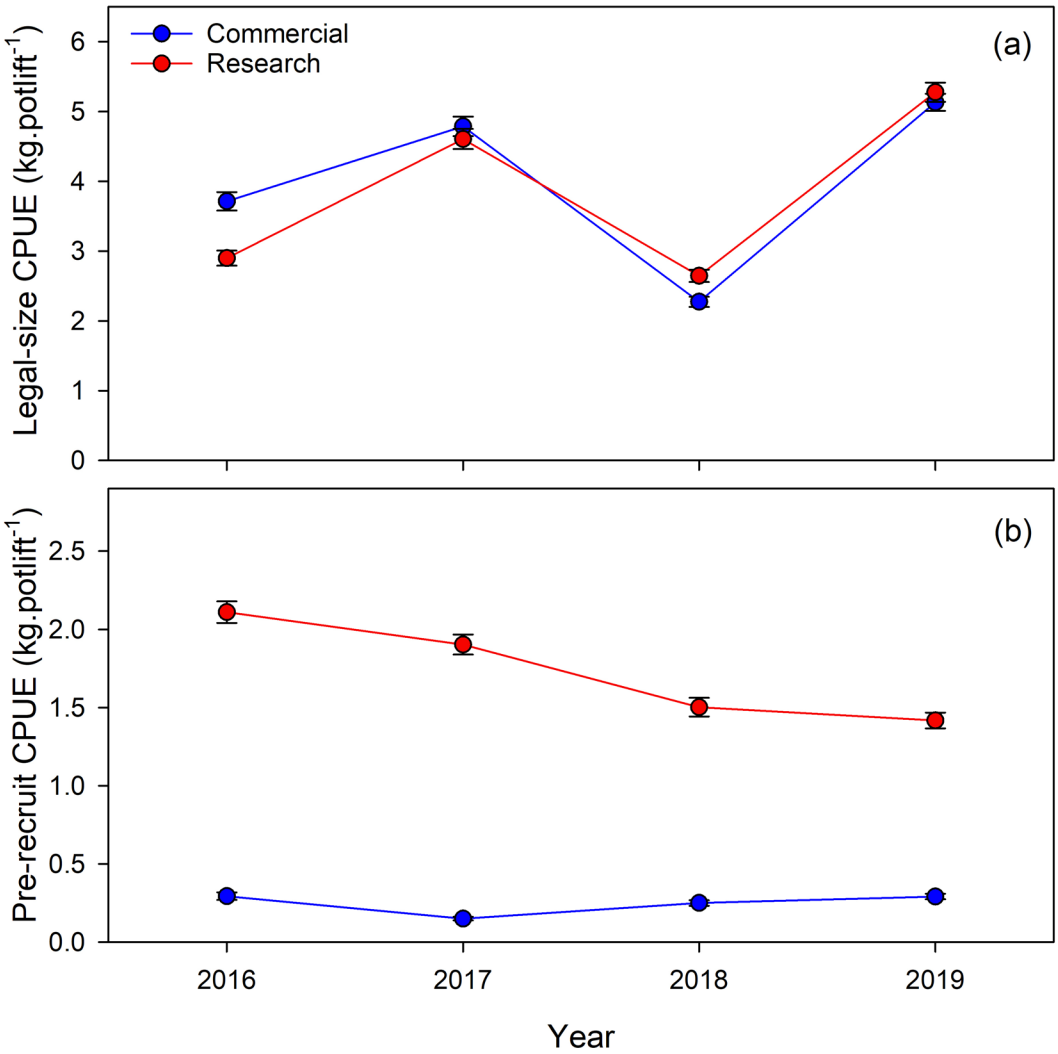

Figure B.1 Mean catch per unit effort (CPUE) of crabs from research and commercial pots from 60 sites sampled from March/April 2016–2019 in Spencer Gulf; (a) legal-size CPUE, and (b) pre-recruit CPUE. Error bars, standard error.

B.2 Gulf St Vincent

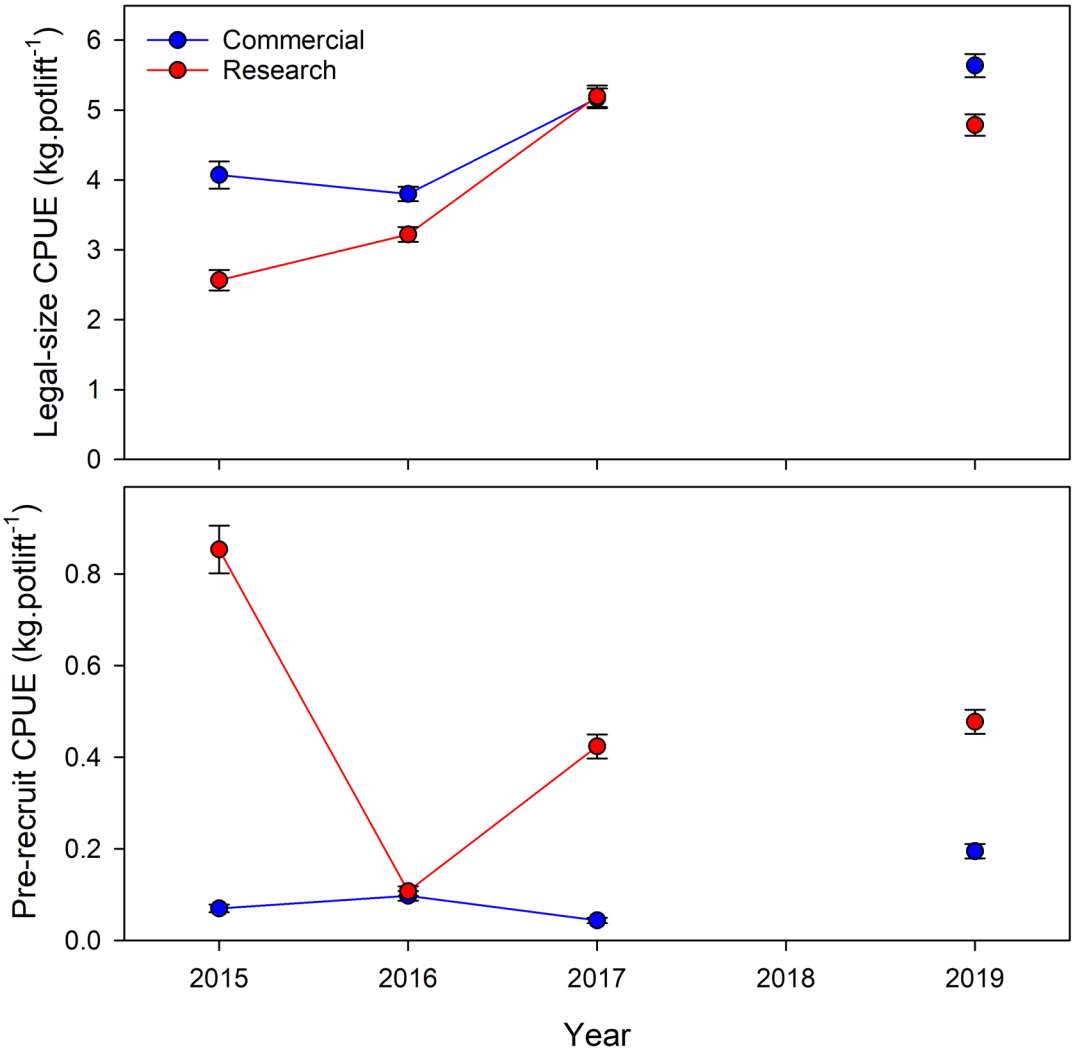

Figure B.2 Mean catch per unit effort (CPUE) of crabs from research and commercial pots from 60 sites sampled from March/April 2015–2019 in Gulf St Vincent; (a) legal-size CPUE, and (b) pre-recruit CPUE. Error bars, standard error. Note- no survey was undertaken during March/April 2018.