Fisheries

Blue Crab (*Portunus armatus*) Fishery 2021-22

C. L. Beckmann and G. E. Hooper

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SARDI Aquatic and Livestock Sciences
PO Box 120 Henley Beach SA 5022

June 2023

Fishery Assessment Report to PIRSA Fisheries and Aquaculture

Government of South Australia
Department of Primary Industries and Regions

SARDI R&D South Australian Research and Development Institute

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EXECUTIVE SUMMARY

This report assesses the status of the Blue Crab (*Portunus armatus*) resource and provides the latest estimates of the biological performance indicator (PI), information in context of the reference points (RPs), and stock status classification described in the 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 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, i.e., legal-size catch per unit effort (CPUE) calculated from fishery-independent surveys (FIS; PIRSA 2020).

Spencer Gulf

In 2021/22, 326.3 t was harvested from SG, which represented 86% of the Blue Crab TACC (381.67 t). This was a 22% decrease in catch compared to 2020/21 (417.5 t) and was the lowest catch since 1998/99 (323.8 t). In 2021/22, estimates of commercial CPUE (legal-size catch-per-boat-day) remained relatively stable and were the fourth highest reported, while estimates of CPUE (legal-size catch-per-pot-lift) decreased by 9% and remained the ninth highest reported over a 25-year period of reporting. Data from the March 2022 FIS indicated that pre-recruit CPUE was the highest recorded and legal-size CPUE was the fourth highest recorded for March/April. In 2022, legal-size FIS CPUE in SG was 4.1 ± 0.3 kg.potlift^{-1}, which was above the trigger RP (2.4 kg.potlift^{-1}). As a result, the SG Blue Crab stock is classified as '**sustainable**' (Table E-1).

Gulf St. Vincent

In 2021/22, 195.1 t was harvested from GSV, which represented 72% of the TACC (269.66 t). While this represented a 12% increase in catch compared to 2020/21 (174.3 t), catches remained below average between July 2021 and January 2022. From 2020/21 to 2021/22, annual estimates of commercial CPUE increased for both catch-per-pot-lift and catch-per-boat day. Data from the March 2022 FIS indicated that legal-size CPUE was the highest on record, while pre-recruit CPUE was the third highest reported since March/April surveys commenced in 2015. In 2022 legal-size FIS CPUE in GSV was 5.4 ± 0.4 kg.potlift^{-1}, which was above the trigger (1.7 kg.potlift^{-1}) and target RP (2.5 kg.potlift^{-1}) defined for this PI. As a result, the GSV Blue Crab stock is classified as '**sustainable**' (Table E-1).

Table E-1. Status of South Australia's Blue Crab Fishery stocks from 2019/20 to 2021/22 assessed against reference points (RP) for legal-size CPUE measured during March/April FIS (research potlifts).

Management Zone	**RPs (legal-size CPUE kg.potlift^{-1})**			**FIS Legal-size CPUE (kg.potlift^{-1}) and stock status**		
	Limit	**Trigger**	**Target**	**2019/20**	**2020/21**	**2021/22**
Spencer Gulf	1.0	2.4	3.7	5.0 ± 0.2 (Sustainable)	2.8 ± 0.1 (Sustainable)	4.1 ± 0.3 (Sustainable)
Gulf St Vincent	0.8	1.7	2.5	4.3 ± 0.1 (Sustainable)	3.0 ± 0.1 (Sustainable)	5.4 ± 0.4 (Sustainable)

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

1. INTRODUCTION

1.1. Background

Stock assessments for the South Australian Blue Crab Fishery (BCF) have been produced annually since 1998 (Svane and Hooper 2004) as part of the South Australian Research and Development Institute (SARDI) Aquatic and Livestock 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. This report updates the 2020/21 stock assessment report (Beckmann and Hooper 2022).

1.2. Objectives

This report has four aims: 1) to present information on the fishery and biology of the species; 2) to assess the status of the Blue Crab resource in Spencer Gulf (SG) and Gulf St Vincent (GSV), and to consider the uncertainty associated with each assessment; 3) to comment on the current biological performance indicator (PI) 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 commercial Fishery valued at $8.4 million (gross value of production; GVP) in 2020/21 (Econsearch 2022).

There are three major stakeholders: the commercial pot fishery (BCF; Figure 1.1), the commercial Marine Scalefish Fishery (MSF; Figure 1.2) and the recreational fishery. Access to take Blue Crabs in the BCF (SG and GSV zones) is provided via a BCF or MSF licence. The SG and GSV zones are under a quota management system with a total allowable commercial catch (TACC), and the licences accessing these zones are endorsed with quota units. MSF licences (with appropriate gear entitlements) are also permitted to take Blue Crabs on the West Coast (WC) of South Australia (west of longitude 135°E). 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 use specifically designed crab pots covered with mesh which are generally hauled once or twice every 24 hours. MSF operators mostly use hoop/drop nets or dab

nets. Recreational fishers mostly use hoop/drop nets or handheld 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; gear endorsement limits on MSF licences limiting number of hoop or drop nets that can be used; 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.

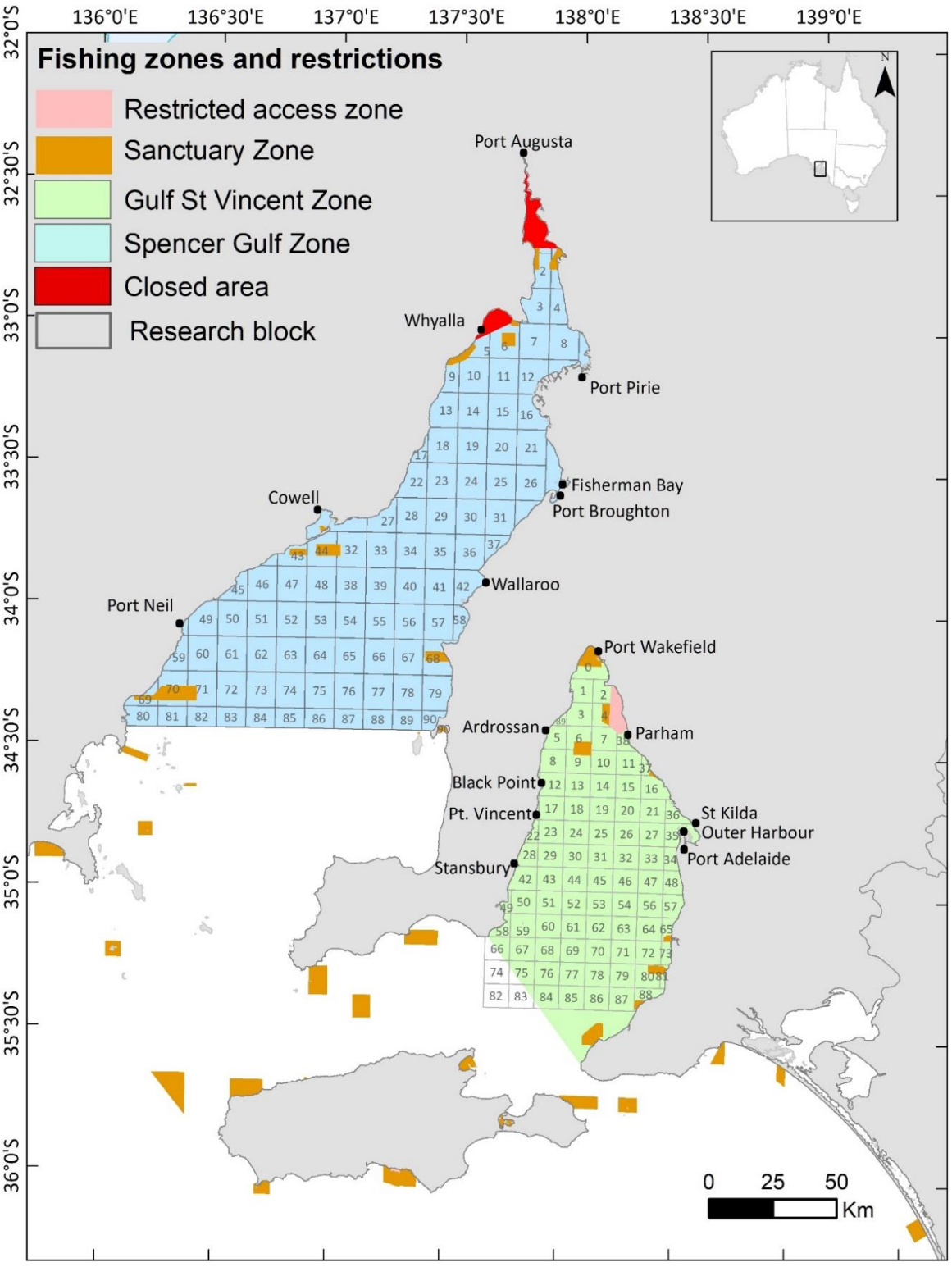

Figure 1.1 The South Australian Blue Crab Fishery with Spencer Gulf and Gulf St. Vincent fishing zones, research blocks and restrictions including closed areas, restricted access and Sanctuary Zones.

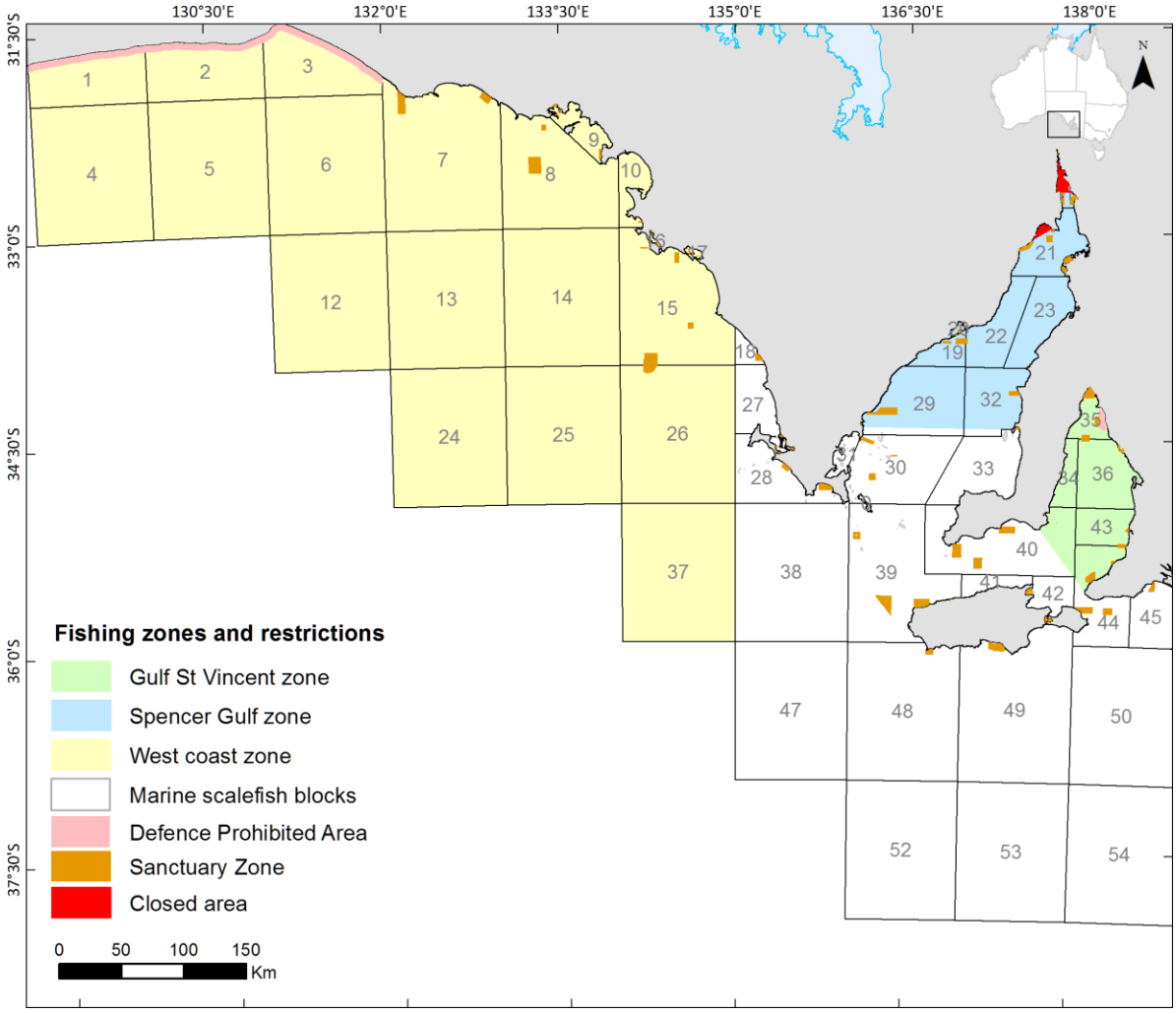

Figure 1.2 South Australian Marine Scalefish Fishery areas and restrictions including closed areas, restricted access and Sanctuary Zones. The Gulf St. Vincent and Spencer Gulf zones are part of the Blue Crab Fishery, and the West Coast zone (not subject to total allowable catch) operates in all waters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

1.3.2. Management arrangements

The BCF was established in 1996 and is managed by the South Australian State Government's Department of Primary Industries and Regions (PIRSA) Fisheries and Aquaculture. 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.

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). 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 increases with depth from January to September and decreases 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 durations of development 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. This is supported by microsatellite analysis which found significant genetic differences between samples from SG, GSV and WC region (Chaplin *et al.* 2001).

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 the PI 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. In addition, an advice note is prepared annually to report on the FIS results. A summary of these results for 2023 are provided in Appendix 1.

1.6. Management Plan

The current *Management Plan for the South Australian Commercial Blue Crab Fishery 2020* (the Management Plan) 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. The key biological PI 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 The primary biological performance indicator and reference points for the Spencer Gulf and Gulf St. Vincent zones of the Blue Crab Fishery under the Management Plan (PIRSA 2020). 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 status of the Blue Crab resource and provides the latest estimates of the biological PI, within the context of the RPs and stock status classification in accordance with the Management Plan. The harvest strategy for the fishery was developed in accordance with the National Fishery Status Reporting Framework (Piddocke et al 2021) classification system to determine the status of all South Australian fish stocks (Table 1.2).

The 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 sustainable (green). When the legal-size CPUE is below the trigger RP, the relative biomass of Blue Crabs is 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 (Piddocke *et al.* 2021).

	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

Fishery-independent surveys (FIS) are conducted using commercial vessels, in combination with independent onboard observers. The primary aim 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 from 2002 to 2018. June/July surveys were not undertaken in SG during 2011, 2013 and 2015 when the CPUE of pre-recruits was above average from the previous 10-years (PIRSA 2012). Full details of the June/July survey dates are available in Beckmann and Hooper (2019). Annual surveys in March/April commenced in 2015 in GSV and in 2016 in SG (Table 2.1). No survey was undertaken in GSV during March/April in 2018 due to the Pacific Oyster Mortality syndrome outbreak.

Table 2.1 Fishery-independent survey (FIS) calendar for Spencer Gulf (SG) and Gulf St. Vincent (GSV) during March and April from 2015 to 2022.

Year	Gulf St Vincent		Spencer Gulf	
	Start Date	**End Date**	**Start Date**	**End Date**
2015	19 March	23 March	No survey	
2016	28 March	2 April	5 April	10 April
2017	13 March	18 March	28 March	2 April
2018	No survey		16 April	21 April
2019	3 March	10 March	18 March	24 March
2020	22 March	27 March	9 March	14 March
2021	14 March	19 March	7 April	12 April
2022	2 March	8 March	21 March	26 March

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, with four sites 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 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.

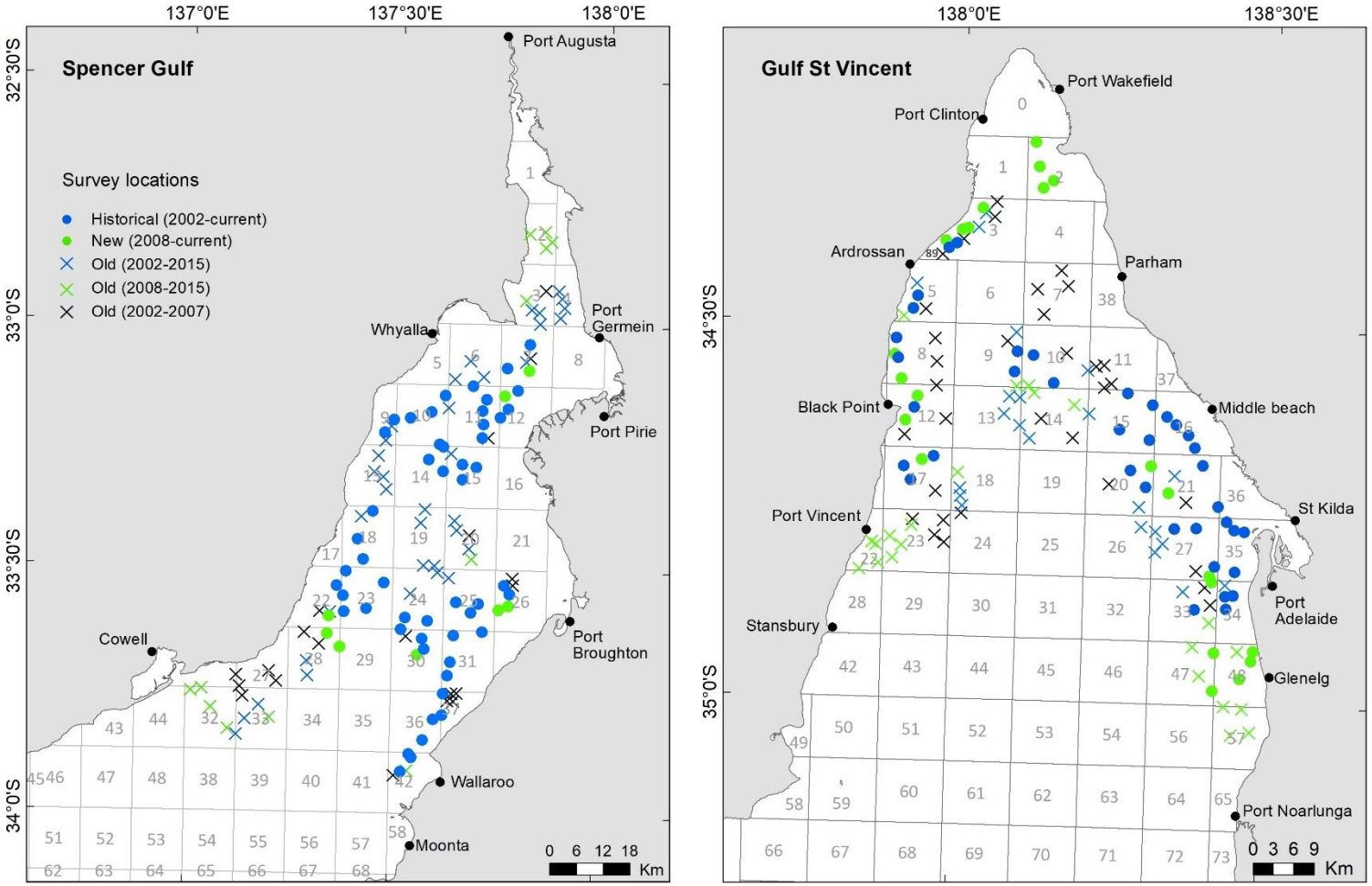

Figure 2.1 Commercial fishing blocks (grid) and fishery-independent survey (FIS) locations in the Spencer Gulf and Gulf St. Vincent zones of the Blue Crab Fishery. Circles represent the 60 sites chosen for the harvest strategy (historical sampled since 2002 in blue, new sampled since 2008 in green), 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.

Paired surveys were undertaken during March/April and June/July from 2015 in GSV and 2016 in SG to inform the transition from March/April to June/July surveys (PIRSA 2020). To achieve this, the number of sites sampled during the FIS were reduced. 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 GSV, the reduction in sites 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 research pots were set and hauled daily. 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. The carapace widths (mm) of captured Blue Crabs were measured using Vernier calipers, and details of sex and condition (dead, soft, berried) were recorded. Research pots are the primary source of data for assessing the performance of the stock as they have remained consistent since surveys commenced (i.e. a diameter of 140 cm, a height of 50 cm, and a mesh size of 5.5 cm). Data from commercial pots is also recorded during surveys, however, the pot type is not standardised between operators or through time, and commercial pots have generally increased in size, with larger mesh and escape gaps becoming common since 2006/07.

Prior to 2022, at each FIS site, five sets of gear were deployed, each set consisting of one commercial pot and one small-mesh pot (except for GSV in July 2012 when only small mesh pots were used). Historically, each set of gear was spaced 150 m apart and, where both pot types were used, pots were separated by 40 m of rope. In recent years, some operators have moved to using long-line gear where pots are set along a single line at each FIS location with sets of gear spaced at 76 m apart. From 2022, a single research pot was set with nine commercial pots. This change to the survey design followed a request for advice from PIRSA F&A on transitioning to commercial pots for obtaining CPUE during FIS in response to high catch rates and mortality of crabs since transitioning to March/April surveys.

From FIS data, nominal CPUE was calculated as the average weight of legal-size blue crabs per potlift and the average weight of pre-recruit blue crabs per potlift. Sex- and gulf-specific weight conversions for each crab length measured were undertaken using the length/weight relationship for June/July (Beckmann and Hooper 2017) or March/April (Figure 2.2). 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. CPUE (crabs.potlift^{-1}) 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.

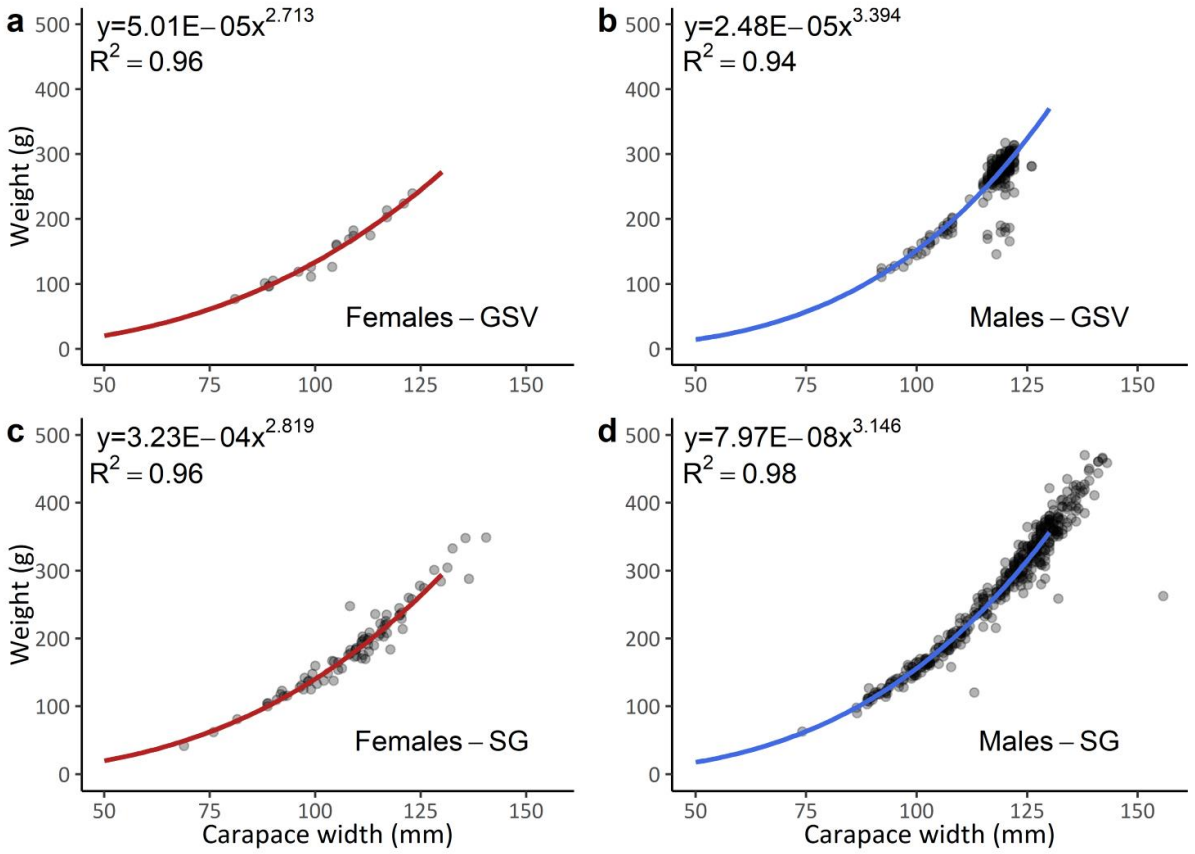

Figure 2.2 Length-weight relationship for Gulf St Vincent (GSV) for (a) female crabs, and (b) male crabs, and Spencer Gulf (SG) for (c) female crabs and (d) male crabs. Data was collected from surveys undertaken during March 2020 and March/April 2021.

2.2. Commercial catch and effort statistics

Commercial catch and effort data are recorded in SARDI logbooks by licensed fishers who operate 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 zone (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 and second lifts). 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. A summary of the key statistics is provided in Appendix 2.

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 five extensive recreational fishing surveys carried out in South Australia over the past 20 years. The first was an on-site (creel) that was undertaken throughout 1994 to 1996 (McGlennon and Kinloch 1997). A national telephone/diary survey supported with an on-site (creel) survey was undertaken in 2000/01 (Henry and Lyle 2003). State-wide surveys using similar methodology were undertaken in 2007/08 (Jones 2009), 2013/14 (Giri and Hall 2015) and 2021/22 (Beckmann *et al.* 2023). The 2013/14 survey included a limited on-site (creel) survey to determine the recreational catch and effort of Blue Crabs in Northern GSV. Of the five published surveys, only the results from the most recent four surveys can be reliably compared, as their data were collected using similar methods.

2.4. Quality assurance of data

All logbook data were entered and validated according to the quality assurance protocols identified for the BCF (Vainickis 2010). Data were stored in an Oracle database, backed up daily, and with access restricted. All FIS data were entered into Excel spreadsheets. Accuracy of data entry was verified by checking a subset (20%) of the data against the original data sheets. Once validated, data were stored on a network drive with restricted access.

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, and since then most has come 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, reaching 662 t in 2007/08. Since then, commercial catch has been relatively stable. In 2021/22, the State-wide catch was 579 t, which was below the previous 10-year average (644 ± 10 t [SE]).

3.1.2. Recreational

In the most recent recreational fishing survey, Beckmann *et al.* 2023 reported that there were 356,708 (± 10,843) South Australian Residents who fished in the 12-months prior to the 2021/22 survey period. Blue Crab were the most caught of all species in SA waters, representing 18% of the total catch by number equivalent to 1,963,340 (± 338,346 SE). The retained catch reported was 920,721 crabs (± 121,102 SE) with most of the catch harvested from the Gulf St Vincent (123 t ± 34 t SE), Spencer Gulf (102 t ± 53 t SE) and West Coast (14 t ± 41 t SE) fishing zones. The 2021/22 recreational catch estimate was 251 t (± 33 t coefficient of variation, CV) which was lower than the previous estimates of 376 t (± 110 t CV) in 2013/14 (Giri and Hall 2015), 284 t (± 34 t CV) in 2007/08 (Jones 2009), and 390 t (± 51 t CV) in 2000/01 (Henry and Lyle 2003). Note that the 2000/01 recreational catch estimate was updated to 1,055,101 crabs (from 1,139,795 crabs) by Jones 2009, which would result in a revised harvest estimate of 361 t (± 60 t CV, shown in Fig. 3.1).

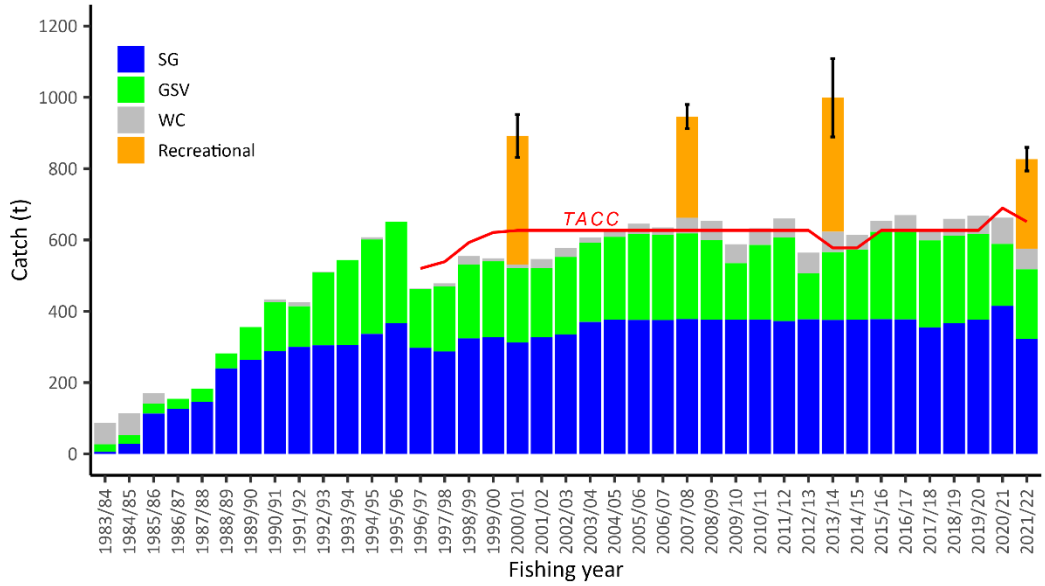

Figure 3.1 State-wide catch including commercial catch (t) of Blue Crabs from 1983/84 to 2021/22 in Spencer Gulf (SG); Gulf St. Vincent (GSV) and from the West Coast (WC), recreational catch (t) estimated in May 2000 to April 2001, October 2007 to September 2008, November 2013 to October 2014, and March 2021 to February 2022. Error bars show ± coefficient of variation (CV).

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. Annual commercial catches progressively increased during the late 1980s and early 1990s and reached a peak of 367 t in 1995/96 (Figure 3.2a). Catches declined in the following two years in response to the introduction of the annual TACC, before increasing to 340 t in 2002/03. From 2003/04 to 2019/20, between 94 and 100% of the TACC was taken, with catches ranging from 359 t in 2017/18 to 382 t in 2007/08. In 2020/21 the TACC increased to 419.8 t, and the resulting catch was the highest on record (418 t). During 2021/22, catch decreased to 326.3 t, the lowest reported since 1998/99 (323.8 t), equating to 85% of the TACC (381.7 t).

3.2.2. Effort

Annual targeted effort in the SG zone increased from 90 boat days in 1983/84 to 1,202 boat days in 1985/86 and remained stable until 2007/08 (mean: 1,183 ± 24 [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 stable since (mean: 718 ± 12 [SE] boat days). In 2021/22, 680 boat days were fished, which was an 8% decrease compared to 2020/21 (740 boat days) and was below the previous 10-year mean (723 ± 14 [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 2008/09 and 2011/12, with a historical low of 84,756 potlifts recorded in 2011/12. From 2011/12 to 2021/22, the total number of potlifts per year has remained stable (mean: 95,333 ± 2,225 [SE]). In 2021/22, a total of 86,329 potlifts were recorded, which was 14% lower than 2020/21 (100,422 potlifts) and the lowest recorded since 2011/12 (84,756 potlifts).

The number of second potlifts increased from 5,718 in 1997/98 to a peak of 60,398 in 2008/09, whereafter they decreased to 7,529 in 2013/14 and then remained stable until 2015/16 (mean: 9,967 ± 1,285 [SE]). No second potlifts were recorded during 2016/17 or 2017/18 and low numbers have been recorded since 2018/19 (range: 15–1,794). In 2021/22, the number of second potlifts was among the lowest reported at 90 potlifts.

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 TACCs in 1996/97, CPUE continued to increase, peaking at 576 kg.boat day^{-1} in 2010/11. From 2011/12 to 2021/22, CPUE has remained relatively stable (mean: 524 ± 10 [SE] kg.boat day^{-1}). However, in 2021/22 CPUE was 480 kg.boat day^{-1}, which was 15% lower than 2020/21 (564 kg.boat day^{-1}) and the lowest reported since 2008/09 (426 kg.boat day^{-1})

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: 3.6–4.4 kg.potlift^{-1}). In 2020/21 and 2021/22, CPUE was 4.1 ± 0.1 (SE) kg.potlift$^{-1,}$ equivalent to the third highest on record.

3.2.4. Spatial distribution of commercial catch

During the past 24 seasons the spatial distribution of catch has been variable in Spencer Gulf (Figure 3.3). The number of blocks fished increased from 16 in 1998/99 to a peak of 40 in 2007/08. Thereafter, the number of blocks fished has fluctuated, ranging from 39 blocks in 2013/14 down to 23 blocks in 2017/18. In 2021/22, 34 blocks were fished, the fourth highest reported.

High catches (≥ ~30 t per block) were recorded from the upper part of the gulf (blocks 2, 3, 7 and 12) in most seasons (Figure 3.3). The area adjacent Port Pirie (block 12) peaked at >60 t in 2006/07, and high catches (>80 t) were observed near Wallaroo (Block 41) in 2012/13. In 2018/19 and 2019/20, the highest catches (> ~60t) have been observed in the upper gulf (Block 3). In 2020/21, the highest catches were observed in the upper gulf, particularly in Block 3, (>60 t), Block 7 (>30 t) and near Port Broughton at Block 26 (>30 t).

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 (prior to 2016/17). From 1997/98 to 2004/05, monthly catches were evenly spread throughout the year, with peaks generally occurring in September, March or April (Figure 3.4). From 2005/06 onwards, a higher proportion of catch was generally harvested early in the season (i.e., from July to November). In 2021/22, the largest proportion of the catch was harvested between July and December (equivalent to 86% of the total annual catch) and in February (21% of the total catch). Catches were below the previous 5-year average in 8 of the 12 months of the 2021/22 season.

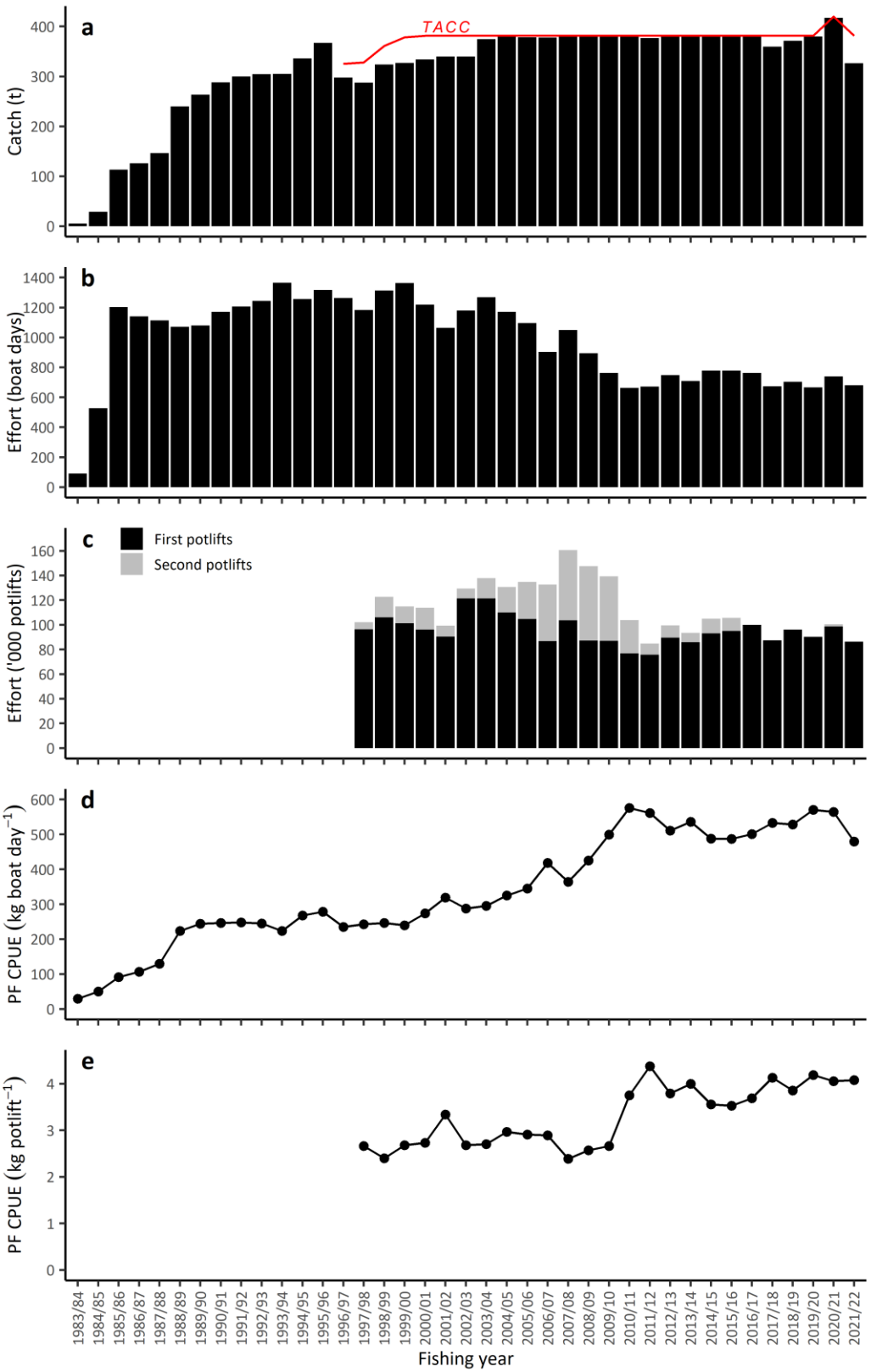

Figure 3.2 Fishery-dependent outputs for the Spencer Gulf zone of the Blue Crab Fishery. (a) Trends in total catch (t) including the total allowable commercial catch (TACC) limit; (b) targeted effort (boat days); (c) total effort from first and second potlifts by the BCF ('000 potlifts); (d) pot fishery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

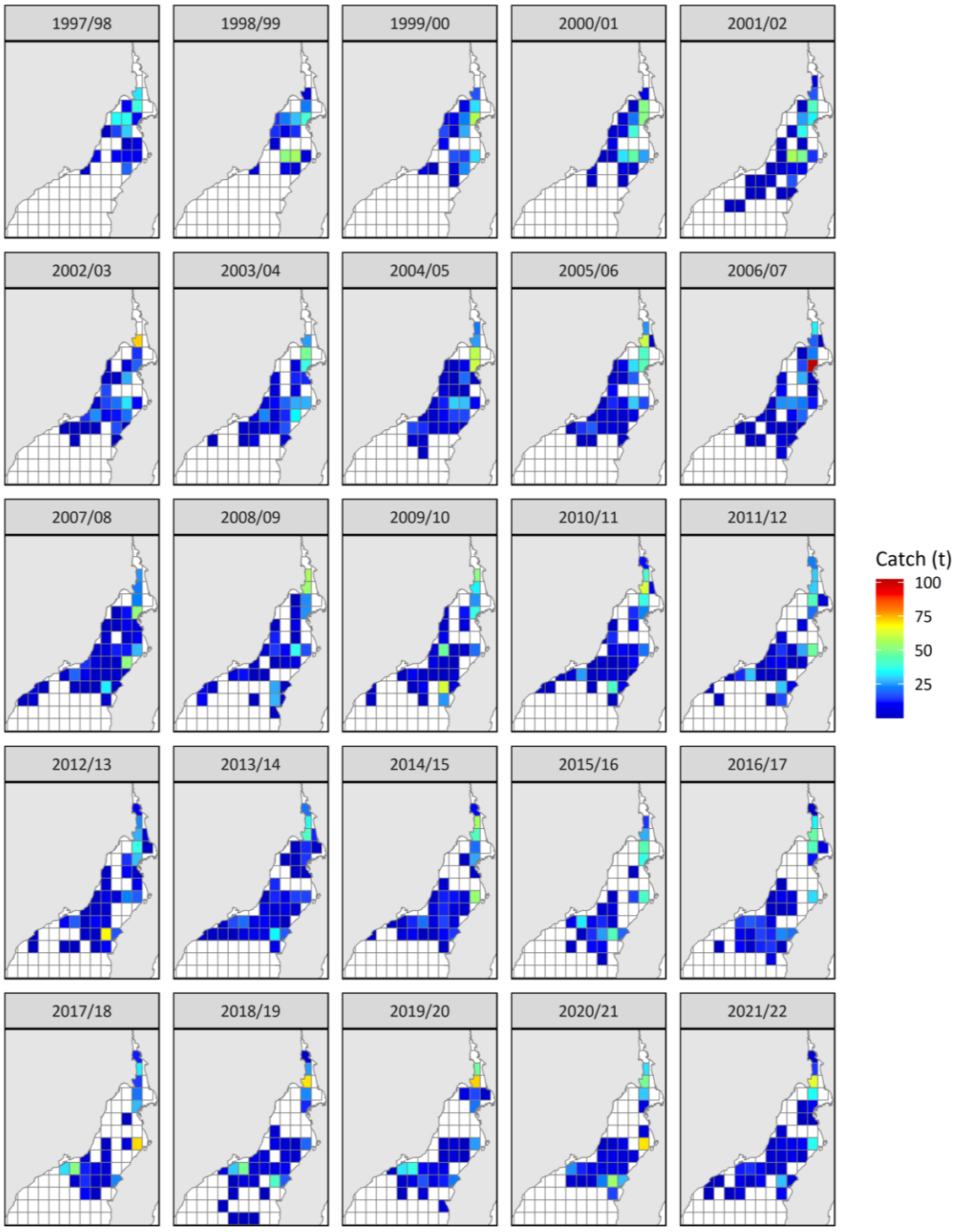

Figure 3.3 Commercial catch (t) reported by block for the Spencer Gulf Zone of the Blue Crab Fishery pot fishing sector from 1997/98 to 2020/21.

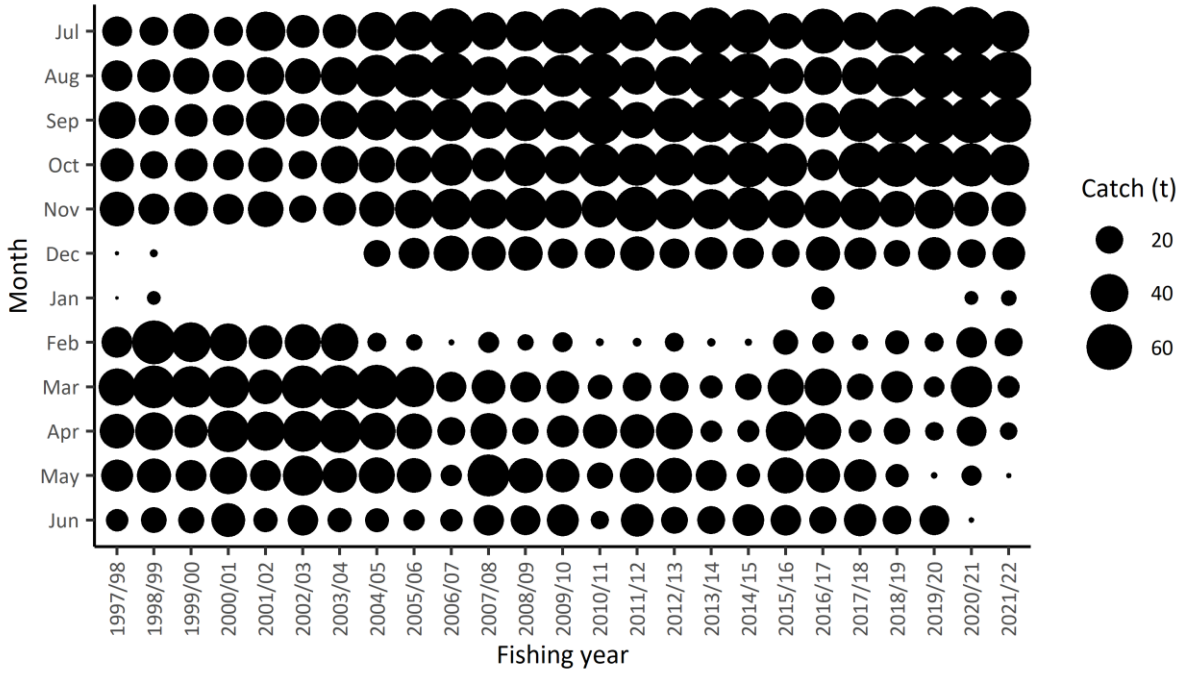

Figure 3.4 Monthly distribution of annual harvest (t) from the Spencer Gulf zone of the Blue Crab Fishery pot fishing sector during 1997/98 to 2020/21. Note: bubble area is proportional to monthly harvest.

3.2.6. Fishery-independent survey CPUE

The June/July CPUE of legal-size crabs increased from 2002 to 2006 (range: 1.4 ± [SE] 0.1 to 2.6 ± [SE] 0.1 kg.potlift^{-1}; Figure 3.5a). 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}). June/July surveys have not been conducted since 2018. The March/April CPUE of legal-size crabs was higher than CPUE from June/July surveys in each year, but followed a similar trend to June/July from 2016 to 2018. The March/April CPUE of legal-size crabs increased by 49% from 2.8 ± [SE] 0.1 kg.potlift^{-1} in 2021 to 4.1 ± [SE] 0.3 kg.potlift^{-1} in 2022, which was the fourth highest value on record for March/April.

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, followed by a large increase in 2007 (1.5 ± [SE] 0.1 kg.potlift^{-1}). The June/July CPUE of pre-recruits at declined to 0.6 ± (SE) 0.0 kg.potlift^{-1} in 2009, before increasing to 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}. No June/July survey has been conducted since 2018. The March/April CPUE of pre-recruit crabs was higher or similar to June/July CPUE in each year and followed a

decreasing trend from 2016 to 2020. The CPUE of pre-recruit crabs was 2.9 ± (SE) 0.2 kg.potlift^{-1} in March 2022, a 65% increase compared to March 2021 (1.7 ± [SE] 0.1 kg.potlift^{-1}) and the highest recorded in March/April.

Spatial density plots indicate that legal-size (Figure 3.6) and pre-recruit (Figure 3.7) blue crabs were broadly distributed throughout FIS sites sampled in March/April in SG during most years. Legal-size crabs were generally concentrated in the northern SG, near Port Pirie and in the central gulf near Port Broughton (Figure 3.7). From 2016–2021, legal-size densities were generally low in most areas. The highest densities were generally observed adjacent to Port Broughton in 2017 (Blocks 25, 30 and 31), and 2019 (Block 24, 30 and 36), near Port Pirie (Block 7 and 12) and adjacent to Port Broughton (Blocks 26, 30 and 31) during 2019 and 2020 and near Port Pirie (Blocks 10, 11 and 15) during 2021. In 2022, legal-size densities generally increased, particularly between Port Broughton and Wallaroo (Blocks 30 and 36), closer to Port Broughton (Blocks 26 and 31) and north of Cowell (Blocks 14, 22 and 23). In 2016 and 2017, relatively high densities of pre-recruits were observed adjacent to Port Pirie (Blocks 11 and 12) and off the Western coastline (Block 18). From 2018 to 2021, pre-recruit density remained low throughout the gulf, with the highest densities generally observed adjacent to Port Broughton (Block 26 and 30), south of Whyalla (Block 10), and near Wallaroo (Block 36). In 2022, pre-recruit density increased, particularly in the area adjacent to Port Pirie (Blocks 7, 11 and 12) and to a lesser extent Port Broughton (Blocks 25, 26, 31).

Sex-specific length-frequency data indicate that a high proportion of male crabs (range: 83–96%) were captured in March/April FISs from 2016 to 2021 (Figure 3.8). In 2016 and 2017, the modal size of male crabs was undersize (105–109 mm CW). From 2017–2021, legal-size male crabs dominated the survey catch (range: 45–71% of the catch). The modal size of male crabs was above the legal-size limit during 2018, 2019 and 2021 (110–114 mm CW), and during 2020 (120–124 mm). In 2022, the modal size for male crabs was below the legal-size limit (105–109 mm), however, catch rates were high across the 100–114 mm size ranges. Female crabs made up a low proportion (range: 4–17%) of the survey catch in all years. In most years, the modal size of female was below the legal size limit, however, increased female size was observed during 2019 and 2020 (mode: 110-114 mm). In 2022, female crabs made up 6% of the catch with a modal size of 100–104 mm.

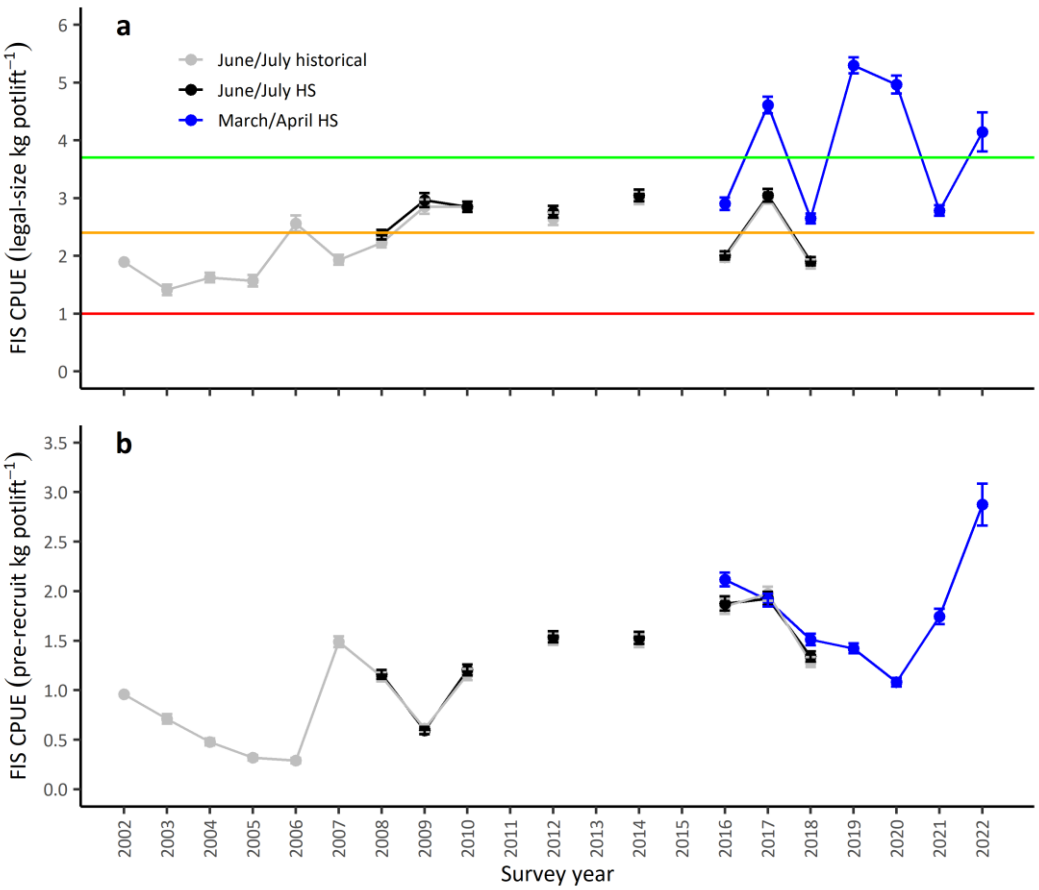

Figure 3.5 Key fishery-independent outputs used to assess the status of the Spencer Gulf zone of the Blue Crab Fishery (BCF). Fishery-independent (FIS) catch per unit effort (CPUE) by weight of (a) legal-size crabs (kg.potlift^{-1}), and (b) pre-recruit crabs (kg.potlift^{-1}). Historical sites refer 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 harvest strategy (see Table 1.1). Error bars show ± SE. Note. June/July surveys were not conducted in 2011, 2013, 2015, 2019–2022.

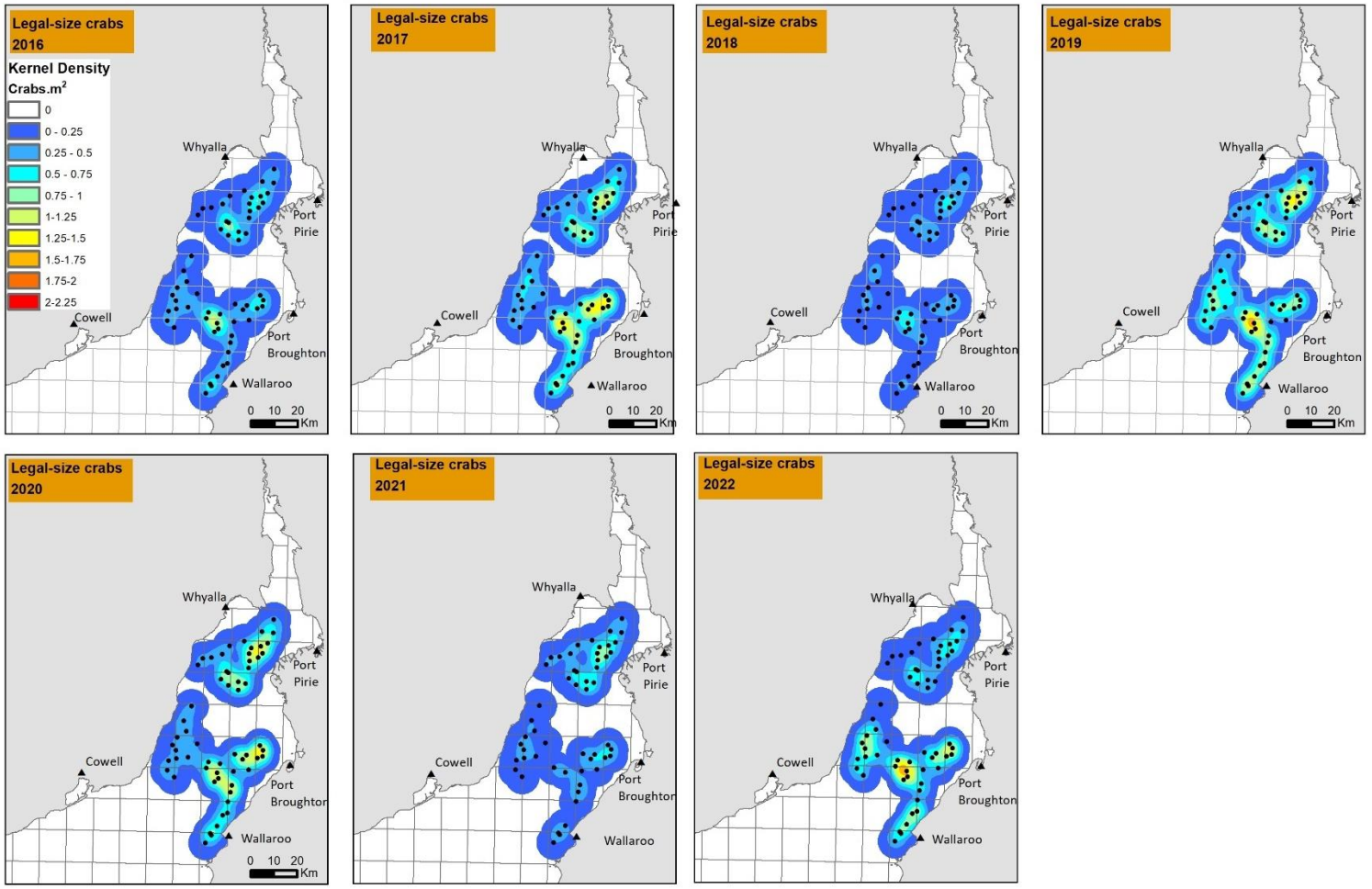

Figure 3.6 Relative density (crabs.m^{-1}) of legal-size crabs from March/April fishery-independent surveys (FIS) in Spencer Gulf. Sampling locations denoted by ●.

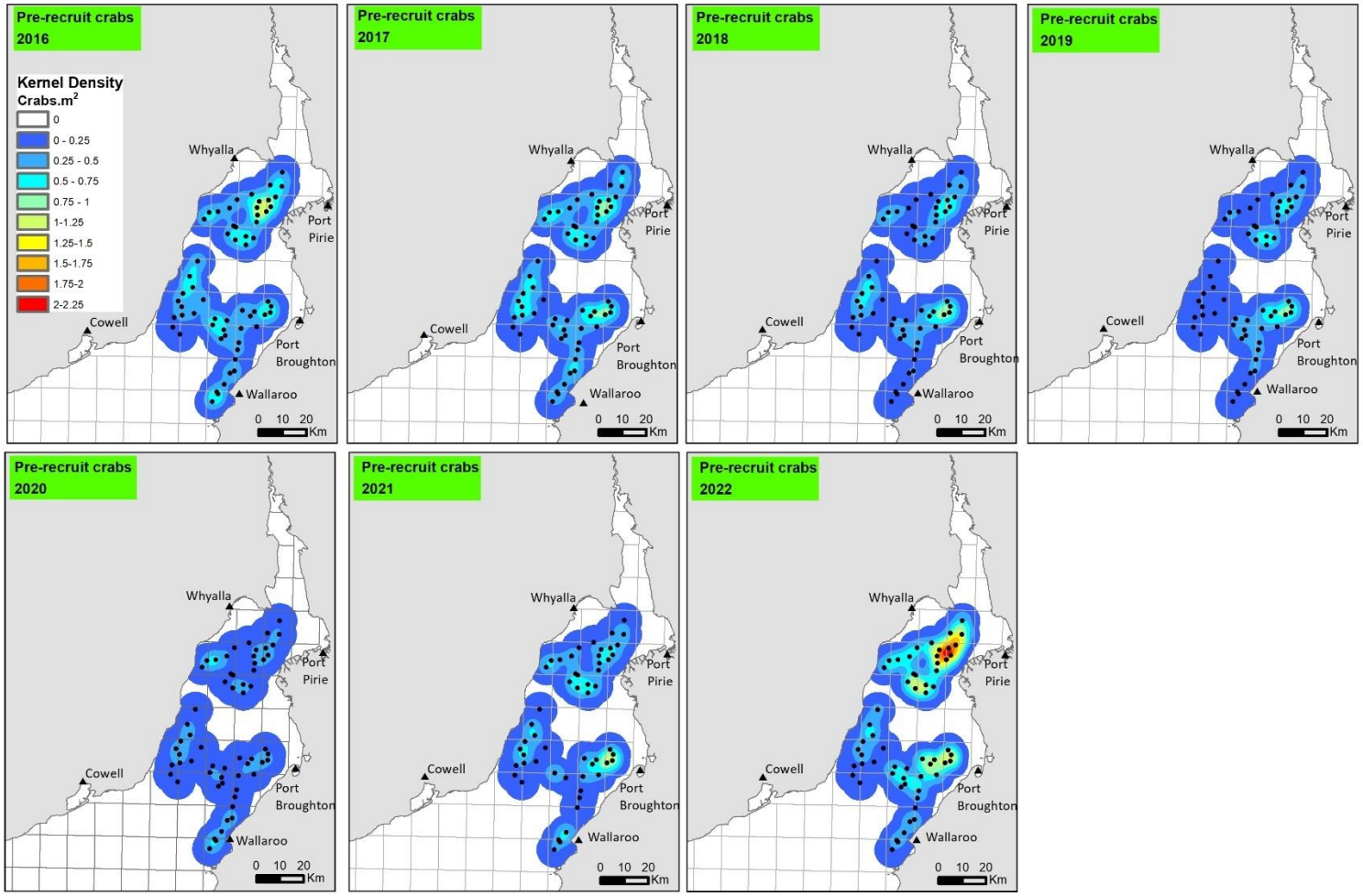

Figure 3.7 Relative density (crabs.m^{-1}) of pre-recruit crabs from March/April fishery-independent surveys (FIS) in Spencer Gulf. Sampling locations denoted by ●.

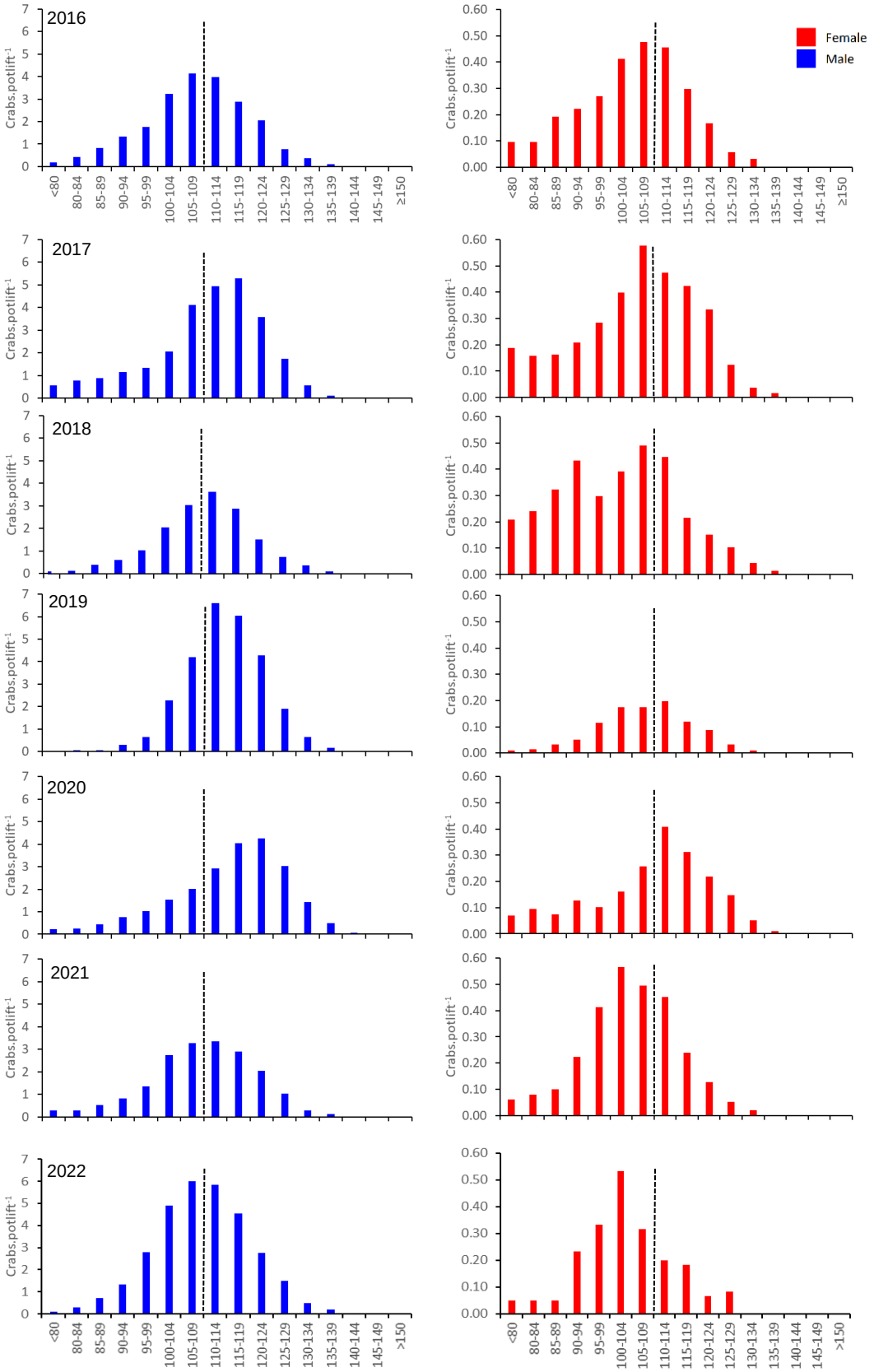

Figure 3.8 Length frequency distributions for male and female Blue Crabs from March/April fishery-independent surveys in Spencer Gulf, sampled at 60 sites selected under the harvest strategy from 2016 to 2021. Minimum size limit 110 mm carapace width, CW (---). Note different Y axis for males and females.

3.3. Gulf St. Vincent

3.3.1. Catch

Since 1990/91 GSV has produced >100 t of Blue Crabs per season. 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 3.9a). Following the introduction of an annual TACC in 1996/97, catch gradually increased from 165 t to 241 t in 2005/06, which comprised 98% of the annual TACC in that year (245.1 t). Thereafter, catch fluctuated, dropping to 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% in 2013/14 to 196 t 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 until 2019/20 the TACC >98% of the TACC was harvested. In 2020/21 and 2021/22, the total GSV harvest was 174.3 t and 195.1 t, respectively. In 2021/22 approximately 72% of the TACC (269.7 t) was caught, a 12% increase compared to 2020/21 but below the previous 10-year average (214 t ± 13 t)

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 3.9b). After the introduction of annual TACC setting, effort was largely transferred to the pot fishing sector, which resulted in a 54% decline in effort to 964 boat days in 1996/97. Effort then progressively declined each year from 1088 boat days in 1997/98 to a historical low of 315 boat days in 2012/13. From 2013/14 to 2021/22, effort has been relatively stable (mean: 469 ± 19 [SE] boat days). In 2021/22, effort was 502 boat days, a 25% increase compared to 2020/21 (401 boat days), and the highest since 2017/18 (515 boat days).

The number of potlifts increased from 49,452 in 1997/98 to a historical maximum of 75,508 in 2005/06 (Figure 3.9c). The number of total potlifts declined to a historical low of 47,677 in 2013/14, thereafter stabilizing at ~60,000 potlifts per year. In 2021/22 there were 65,266 total 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. In 2020/21, there were 1,063 second potlifts, before declining to 357 second potlifts in 2021/22.

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 3.9d). Thereafter, CPUE has fluctuated, ranging from 349 kg.boat day^{-1} in 2009/10 to a historical maximum of 573 kg.boat day^{-1} in 2019/20. CPUE subsequently declined and in 2021/22 was 389 kg.boat day^{-1}, which was an 11% decrease compared to 2020/21 and the lowest reported since 2009/10 (349 kg.boat day^{-1}).

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 3.9e). CPUE then 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 was then relatively stable from 2013/14 to 2019/20 (range: 3.3–3.9 kg.potlift^{-1}), before decreasing to 2.7 ± 0.1 (SE) kg.potlift^{-1} in 2020/21. In 2021/22 CPUE was 2.9 ± 0.1 (SE) kg.potlift^{-1} which was an 8% increase compared to 2020/21 and was the eighth lowest value recorded.

3.3.4. Spatial distribution of commercial catch

The spatial distribution of catch has been variable in GSV over the past 20 seasons (Figure 3.10). The number of blocks fished generally increased from 11 blocks in 1998/99 to 24 blocks in 2008/09. From 2008/09, the number of blocks fished remained relatively stable, ranging from 18 blocks in 2019/20 to 28 blocks in 2015/16. While there is variation in catch distribution among years, no more than ~90 t is harvested annually 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 consistent catches (> ~20 t) from Blocks 21, 27 and 33, with high catches (> ~60 t per block) occurring from 2002/03 to 2006/07. From 2006/07 to 2011/12, relatively high catches were observed along the western coastline, particularly Block 17 (~20–30 t). From 2014/15 to 2017/18, relatively high catches (~40–45 t) occurred in Blocks 33 and 47 adjacent to Port Adelaide and Glenelg. During 2018/19, ~30–40 t per block was again harvested from the Metro area, particularly Blocks 27, 33 and 48. During 2019/20, high catches (~30 t per block) were reported off the Metro coast (Block 33) and near Black Point (Block 12). Lower catches (≤ 25 t) were reported across all blocks fished in 2020/21 and 2021/22, with the exception of Block 17 which saw moderate catches during 2021/22 (~45 t).

3.3.5. Temporal distribution of commercial catch

Blue Crabs are generally harvested throughout the year except during historical 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, or from November and December from 1997/98 to 2014/15 due to the historical closure period. From 1997/98 to 2014/15, most of the catch was harvested in the second half of the season (January–June), with peak catches generally occurring during February or March (Figure 3.11). From 2015/16 to 2017/18 and 2019/20, most of the catch occurred during the first half of the season (July – December), however, high catches (>50 t per year) were maintained from January–March. In 2020/21 and 2021/22, most of the catch was taken from January–June, with the highest catches occurring during March. In 2021/22, catches were below the previous 5-year average during July–January, while above average catches were observed from February–June.

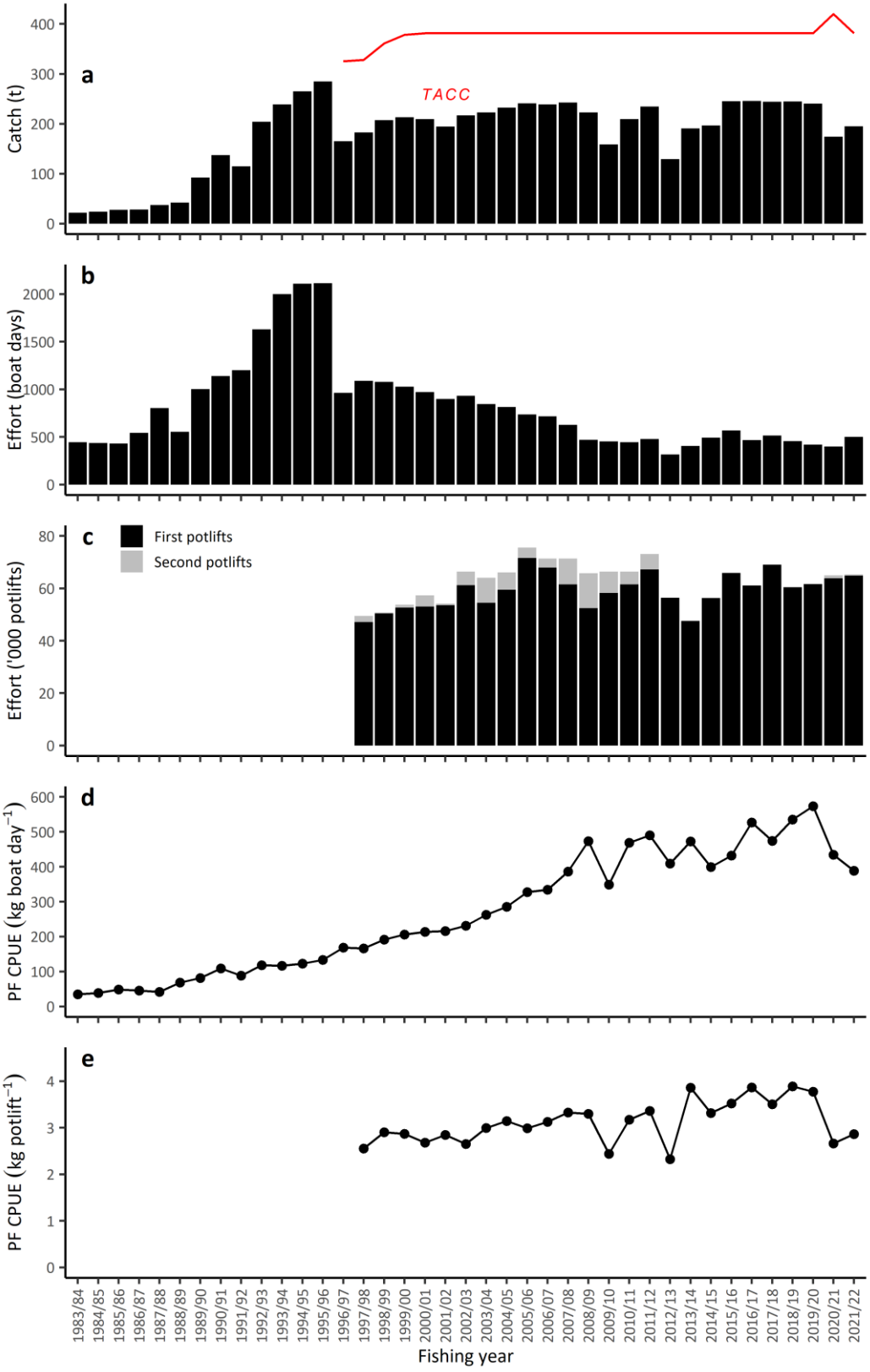

Figure 3.9 Fishery-dependent outputs for the Gulf St. Vincent zone of the Blue Crab Fishery; (a) trends in total catch (t) including the total allowable commercial catch (TACC) limit, (b) targeted effort (boat days), (c) total effort from first and second potlifts by the BCF, (d) pot fishery (PF) catch per unit effort by day (CPUE, kg.boat.day^{-1}), and (e) PF CPUE by potlift (kg.potlift^{-1}).

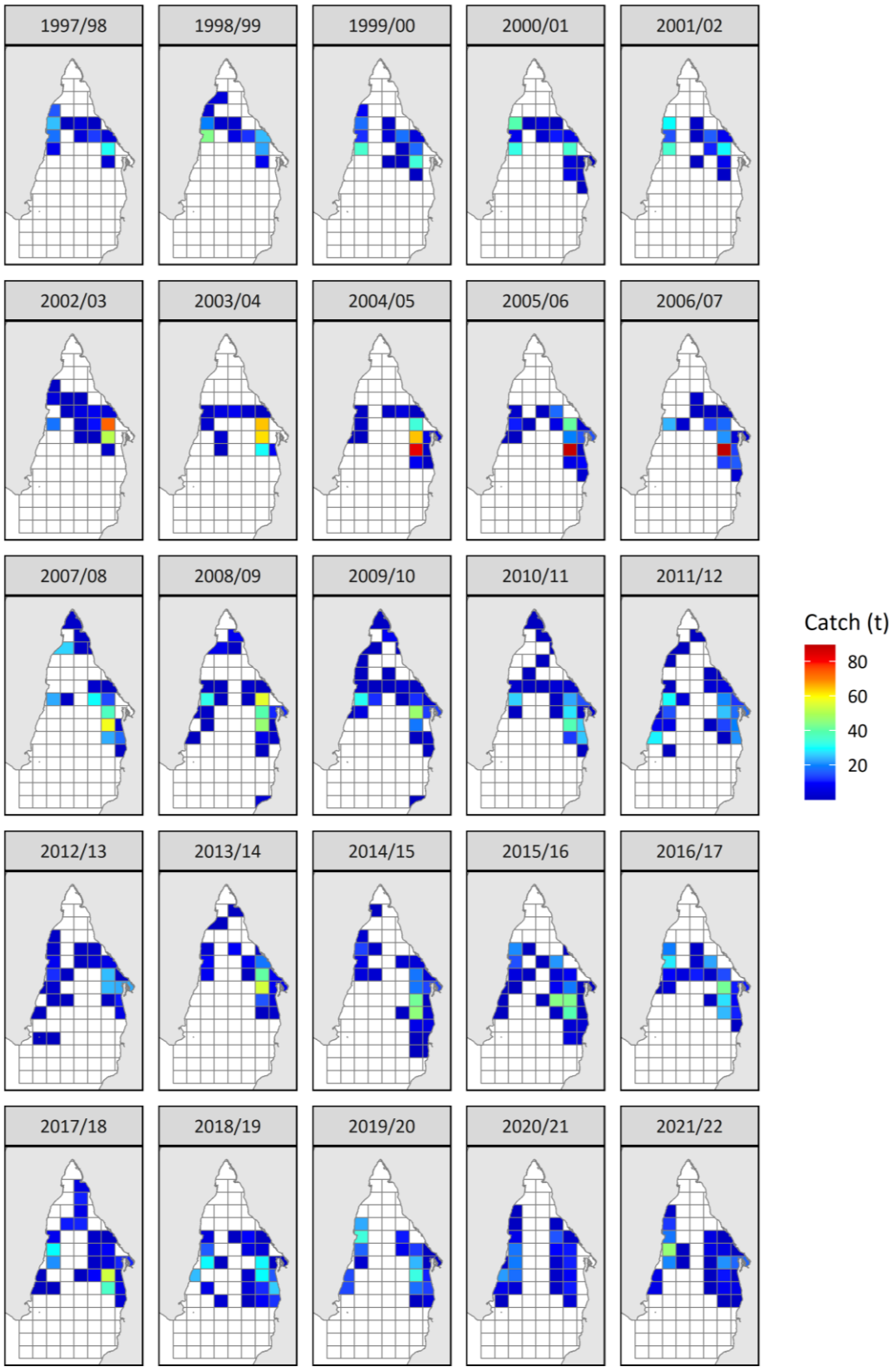

Figure 3.10 Commercial catch reported by block for the Gulf St. Vincent Zone of the Blue Crab fishery pot fishing sector from 1997/98 to 2021/22.

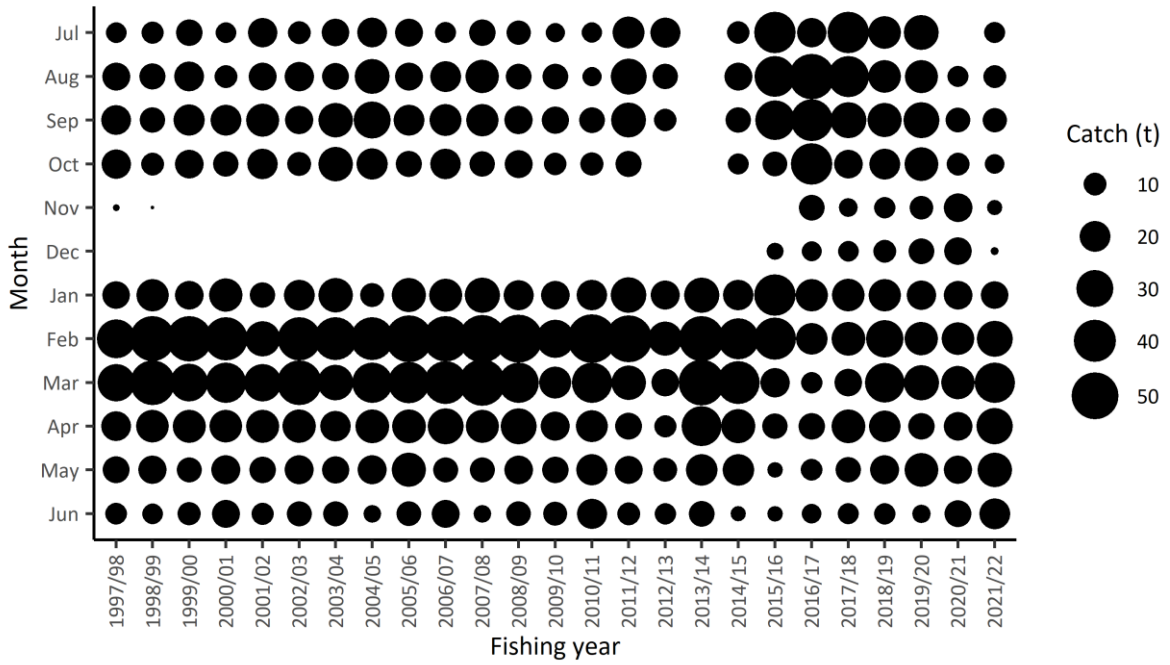

Figure 3.11 Monthly distribution of annual harvest from the Gulf St. Vincent zone of the Blue Crab Fishery pot fishing sector during 1997/98 to 2021/22. Note: bubble area is proportional to monthly harvest.

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 3.12a). From 2008, the June/July CPUE of legal-size crabs at historical sites followed a similar trend to locations selected under the harvest strategy. From 2008 to 2013, June/July CPUE of legal-size crabs declined, dropping to a historical low of 0.5 ± 0.1 (SE) kg.potlift^{-1} in 2012 and 2013 at harvest strategy 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. In 2018, June/July CPUE of legal-size crabs decreased 50% to 1.4 ± 0.1 (SE) kg.potlift^{-1} but was still the fourth highest on record. No June/July surveys have been conducted since 2018.

During 2015 and 2016, legal-size CPUE continued to increase, with record high values observed during June/July and similar values observed in March/April (Figure 3.12a). From 2016 to 2017, the legal-size CPUE in March/April 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}), which was the highest value on record. June/July legal-size CPUE remained high (2.8 ± 0.1 [SE] kg.potlift^{-1}) during 2017 before decreasing to 1.43 ± 0.1 (SE) kg.potlift^{-1} in 2018. No survey was undertaken during March/April 2018 and June/July surveys were discontinued in 2019. In March 2019 and 2020 the legal-size CPUE remained relatively high (range: 4.4–4.8 kg.potlift^{-1}) before decreasing by 32% to 2.9 ± 0.1 [SE] kg.potlift^{-1}) in 2021. In 2022, the legal-size CPUE increased by 82% to 5.4 ± 0.4 [SE] kg.potlift^{-1} and was the highest reported for March/April.

The June/July CPUE of pre-recruits recorded by the FIS has fluctuated since 2002 (Figure 3.12b). 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}). No June/July surveys have been conducted since 2018.

The March/April CPUE of pre-recruit crabs was lower than June/July CPUE in each year and generally followed a similar trend to June/July from 2015 to 2017, noting that no March/April survey data was available for 2018 (Figure 3.12b). The March/April CPUE of pre-recruit crabs was relatively low prior to 2021, ranging from 0.1 ± 0.0 (SE) kg.potlift^{-1} in 2016 to 1.0 ± 0.0

(SE) kg.potlift^{-1} in 2020. In 2021, the March/April CPUE of pre-recruit crabs was 3.5 ± 0.1 (SE) kg.potlift^{-1}, this was a 260% increase compared to 2020 and the highest on record. In 2022, the CPUE of pre-recruit crabs decreased by 69% to 1.1 ± 0.1 [SE] kg.potlift^{-1} and was the third highest reported for March/April.

Legal-size densities were relatively low during 2015 and 2016, with the highest densities observed on the West Coast (Block 3, 8, and 89) in 2016, and the Central gulf (Block 10), in 2016 (Figure 3.13). In 2017, 2019 and 2020 legal-size crabs were found in high densities on the western coastline (Blocks 3, 8 and 89), metropolitan coastline (Blocks 16 and 21) and northern beaches (Blocks 2 and 16). In 2019 and 2020, increased densities were also observed off the metropolitan coastline (Block 33, 34, 35), northern beaches (Block 16), and near black point (Block 17). In 2021, legal-size crab densities were higher along the metropolitan coast (Blocks 21, 33, 34 and 35) and towards Glenelg (Block 47 and 48). During 2022, legal-size densities were widely spread on the western coastline (Blocks 5, 8, 12, 17 and 89), and near Port Adelaide (Blocks 33 and 34).

Pre-recruit densities were relatively low prior to 2020. In 2020, pre-recruit densities increased particularly off the metropolitan coastline (Blocks 47 and 48; Figure 3.14), before becoming more widespread in 2021 with high densities off the metropolitan coastline (Blocks 35, 47 and 48) and south of Ardrossan (Blocks 12 and 17). A large proportion of the gulf had high densities of pre-recruits in 2021, particularly the metropolitan coastline (Blocks 27, 33, 34, 35 and 48), northern beaches (Blocks 2, 10, 15, 16, 20, and 21), and western coastline (Blocks 3, 8, 9. 12 and 89). During 2022, low pre-recruit densities were observed throughout the gulf.

Sex-specific length frequency data indicate that a high proportion of male crabs (range: 91–98%) were captured during March/April surveys. Prior to 2021, legal-size male crabs dominated the catch (range: 58–92% of the total catch), with modal sizes male crabs ranging from 120–124 mm during 2015, 2016 and 2020 and increasing to 125–129 mm in 2017 (Figure 3.15). During 2021, the catch was dominated by undersize males (62% of total catch), with high catch rates observed for crabs in the 105–109 mm size class. In 2022, the catch was mostly legal-size male crabs (76% of total catch) with a modal size of 115–119 mm. In all years, female crabs made up a low proportion of the catch (range: 2–9%). In most years, the modal size of female crabs was above the legal-size limit, ranging from 110–114 mm in 2016, up to 115–119 mm in 2020. The modal size was below the legal-size limit in 2015 (105–109 mm), 2021 (100–104 mm), and 2022 (105–109 mm).

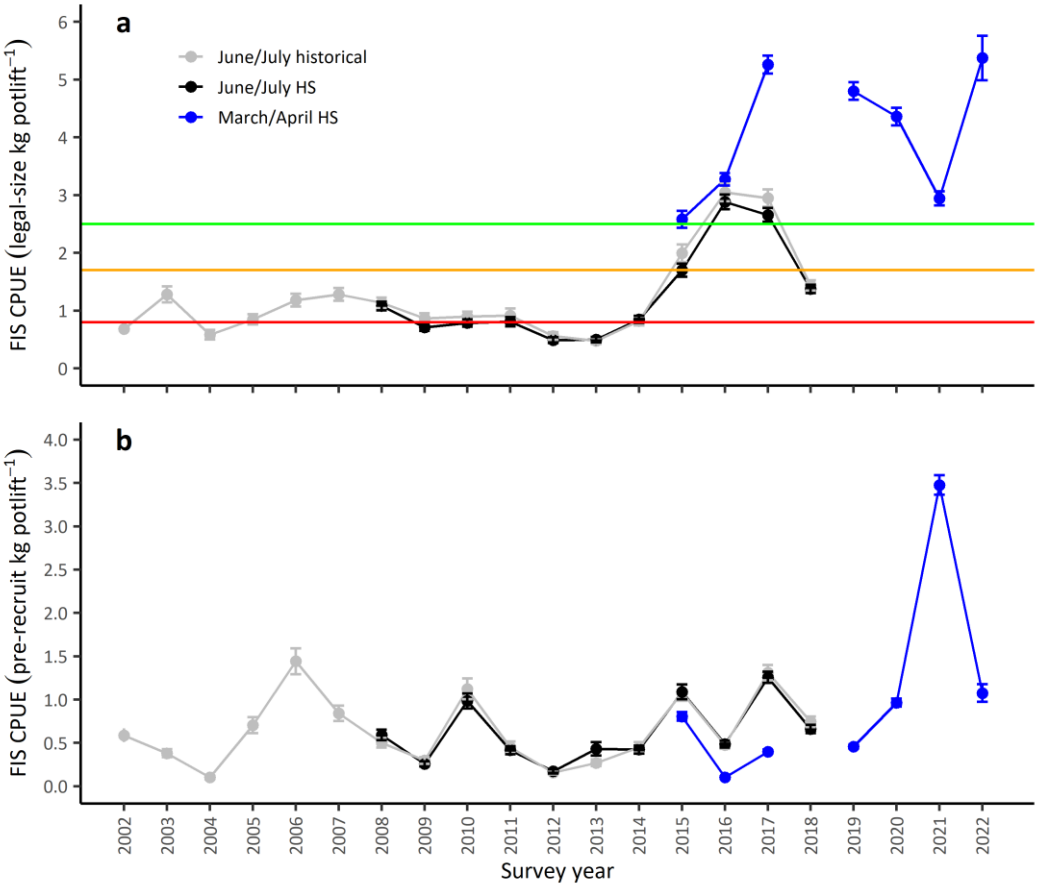

Figure 3.12 Key fishery-independent outputs used to assess the status of the Gulf St. Vincent zone of the Blue Crab Fishery (BCF). Fishery-independent (FIS) catch per unit effort (CPUE) by weight of (a) legal-size crabs (kg.potlift^{-1}), and (b) weight of pre-recruit crabs (kg.potlift^{-1}). Historical 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 harvest strategy (see Table 1.1). Error bars show ± SE. Note: no survey was conducted in March/April 2018 or June/July 2019–2021.

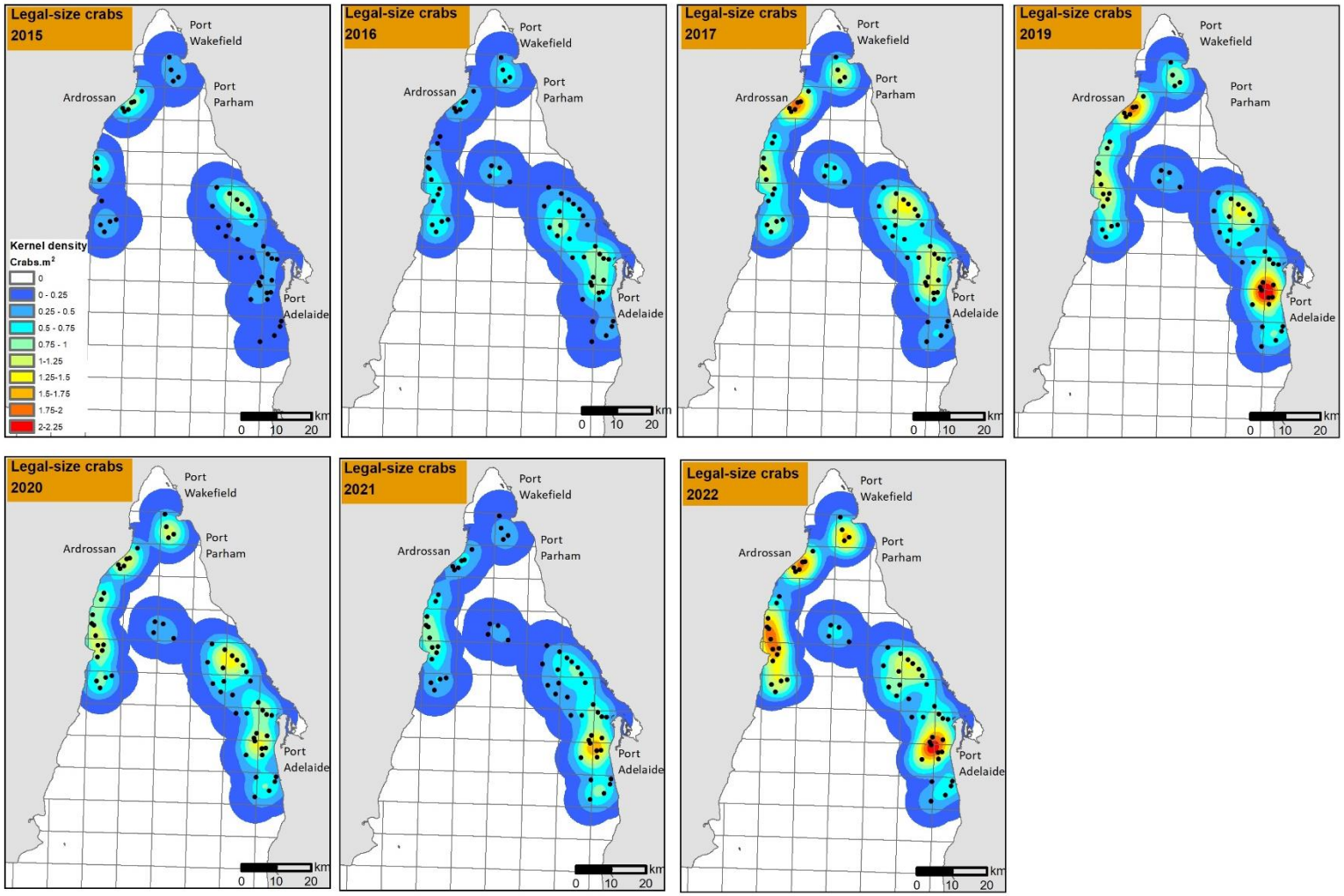

Figure 3.13 Relative density (crabs per square metre) of legal-size crabs from March/April fishery-independent surveys (FIS) sampled in Gulf St. Vincent. Sampling locations denoted by ●. Note: no survey was conducted in March/April 2018.

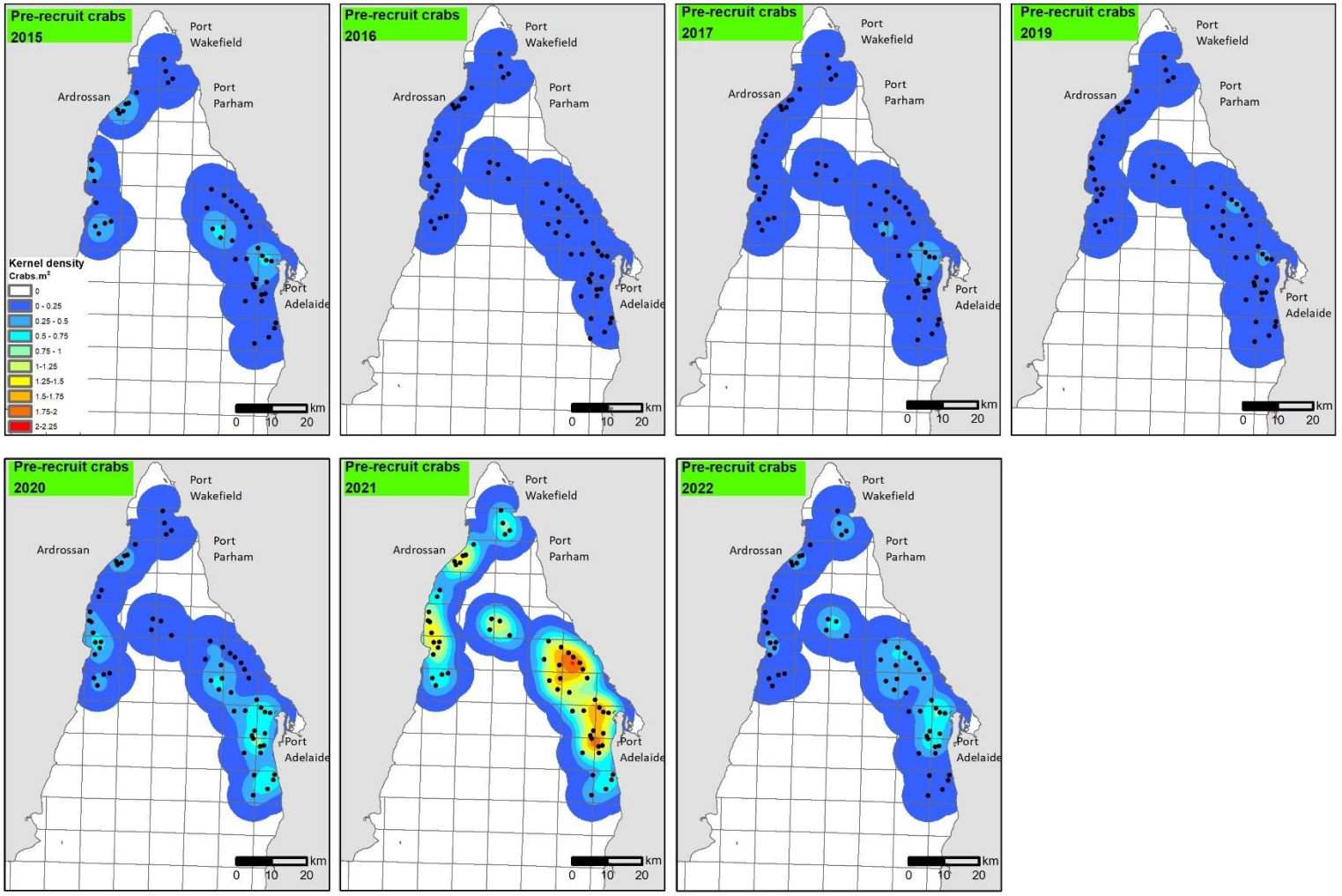

Figure 3.14 Relative density (crabs per square metre) of pre-recruit crabs from March/April fishery-independent surveys (FIS) sampled in Gulf St. Vincent. Sampling locations denoted by ●. Note: no survey was conducted in March/April 2018.

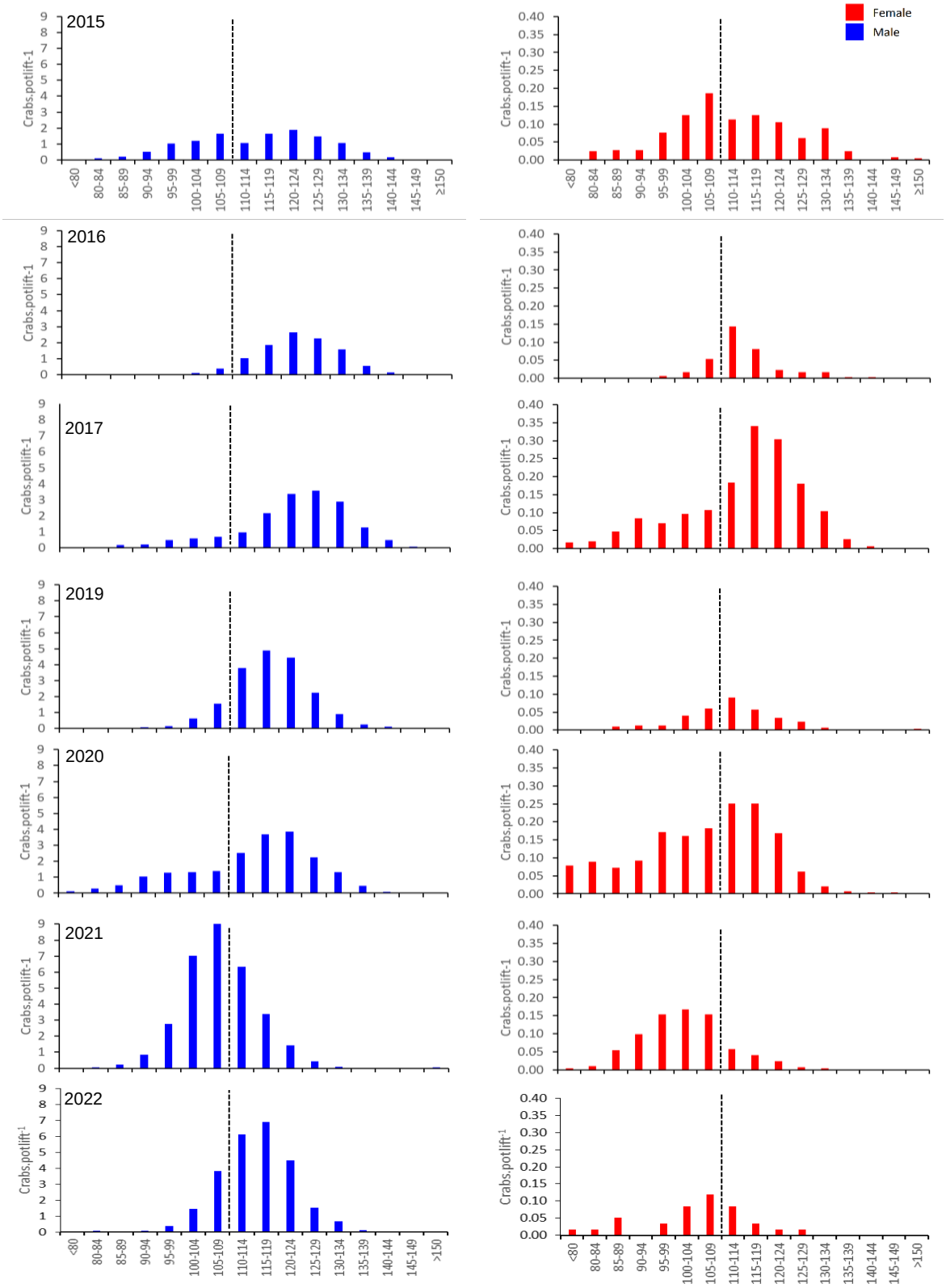

Figure 3.15 Length frequency distributions of male and female Blue Crabs from March/April fishery-independent surveys in Gulf St. Vincent sampled at 60 sites selected under the harvest strategy from

2015–2022. Minimum size limit 110 mm carapace width, CW (---). Note: no survey was conducted in March/April 2018. Note different Y axis for males and females.

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 Management Plan. For SG, the CPUE of legal-size crabs measured in research pots during 2021/22 (4.1 kg.potlift^{-1}) was above the target (3.7 kg.potlift^{-1}) and trigger (2.4 kg.potlift^{-1}) reference points (Table 3.1). Similarly for GSV, the CPUE of legal-size crabs measured in research pots during 2021/22 (5.4 kg.potlift^{-1}) was above the target (2.5 kg.potlift^{-1}) and trigger (1.7 kg.potlift^{-1}) reference points.

Table 3.1 Summary of the performance of the Spencer Gulf (SG) and Gulf St. Vincent (GSV) pot fishing zones for 2019/20–2021/22. The key biological performance indicator (PI) under the harvest strategy in the Management Plan is presented for the SG and GSV (PIRSA 2020).

Zone	Reference Point				Research pot - March/April Legal-size CPUE (kg.potlift^{-1})		
	Limit	Trigger	Target		2019/20	2020/21	2021/22
SG	1.0	2.4	3.7		5.0	2.8	4.1
GSV	0.8	1.7	2.5		4.3	3.0	5.4

4. DISCUSSION

4.1. Information sources used for assessment

4.1.1. Primary biological performance indicator

The primary biological PI used to determine stock status and the annual TACC for the BCF is legal-size CPUE measured during the March/April FIS, which provides an index of relative biomass and fishing mortality. Since 2002, a comprehensive FIS program has been conducted and these data make the primary contribution to assessing stock status. The methods used to collect the data have remained relatively consistent (Beckmann and Hooper 2017). While June/July surveys have been completed from 2002 to 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 Management Plan are CPUE of pre-recruits (kg.potlift^{-1}), as measured during the March/April FIS, and commercial CPUE of legal-sized crabs (kg.potlift^{-1}) (PIRSA 2020). The FIS data are considered to provide the most reliable indices of relative abundance 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 which was discontinued in 2018.

4.2. Stock status

4.2.1. Spencer Gulf

From 2011/12 to 2020/21, the SG zone of the BCF was classified as ‘sustainable’. The annual TACC was nearly fully harvested (≥ 98%) in all years except for 2017/18 and 2018/19 when catch was below the TACC by 22 t and 10 t, respectively. The TACC was maintained at 381.7 t from 1998/99 to 2019/20, before increasing to 419.8 t in 2020/21 and 2021/22. Following the highest catch on record in 2020/21 (417.5 t), the total catch decreased to 326.3 t in 2021/22 equivalent to

an under-catch of 93.5 t. This was reflected in below average catches throughout most of 2020/21, particularly from March–June. Overall trends in CPUE for catch-per-potlift have been relatively stable over the past three years, despite a decline in CPUE during 2021/22 when expressed as catch-per-boat-day. The downward trend in CPUE may be partly explained by the high catch rates of small legal-size crabs, similar to what was observed in GSV during 2020/21 (see Beckmann and Hooper, 2022). Fishers were also operating at reduced capacity due to ship building delays, and La Niña conditions persisted over much of the 2021/22 season resulting in cold water anomalies during this period (Appendix 3, IMOS 2022).

The recent trends in FIS data reflect large fluctuations in legal-size CPUE, particularly since March/April surveys commenced in 2016. The 2022 legal-size CPUE was nearly double the 2021 CPUE and was the fourth highest value on record for March/April. The pre-recruit CPUE reflected high relative biomass, with the highest value on record observed in 2022.

In 2021/22, legal-size CPUE was 4.1 ± 0.3 (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**'.

4.2.1. Gulf St. Vincent

From 2013/14 to 2021/22, the GSV zone of the BCF was classified as 'sustainable'. The TACC was set at 245.1 t from 2015/16 to 2019/20 and during this period, ≥ 98% was harvested. In 2020/21, the TACC was increased from 245.1 t to 269.7 t in accordance with the harvest strategy decision rules, with a reported under-catch of 95.4 t. A further TACC increase to 294.2 t took place in 2021/22 and this resulted in an under-catch of 99.1 t. Similar to 2020/21, below average catches were observed from July–January, however, catches were above average from February–June during 2021/22. This was reflected in an 8% increase in CPUE (catch-per-potlift) compared with 2021/22, despite a further decline in CPUE when expressed as catch-per-boat-day. As was the case in Spencer Gulf, fishers continued operating at reduced capacity due to ship building delays, and La Niña conditions persisted (Appendix 3, IMOS 2022).

The trends in FIS data reflect fluctuations in legal-size biomass, with high catch rates reported in four of the previous seven surveys. From 2019–2021, legal-size CPUE saw consecutive annual declines, but CPUE remains above historical levels. During 2022, legal-size CPUE was the highest reported. Pre-recruit CPUE has fluctuated through time with high values observed in

2006, 2010, 2015, 2017 and 2021. In 2022, legal-size CPUE was well below 2021, but remained the third highest reported for March/April.

In GSV, the 2020/21 legal-size CPUE was 5.4 ± 0.4 (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. Challenges and future research

Several key uncertainties were discussed in detail in the previous assessment (see Beckmann and Hooper 2021). Briefly, while fishery-independent surveys continue to provide the most suitable data set to derive proxies for relative biomass to assess the stock status of Blue Crabs, the interpretation of trends in CPUE is hampered by gaps in the time series, and uncertainties surrounding the relationship between CPUE and stock abundance following the transition from June/July to March/April surveys.

Survey design was also modified during 2022 to address concerns around high levels of mortality observed in research pots. Namely, the number of research pots sampled per site was reduced from five to one. This followed a desktop study which determined the trend in CPUE was maintained using the reduced number of research pots. The advantage of maintaining the research pot time series is that pre-recruits are retained and pre-recruit CPUE can continue to be monitored, providing important insights into the potential future biomass. Furthermore, the existing reference points can continue to be assessed until it is possible to develop new reference points using CPUE from commercial pots. Initial analysis identified that for Spencer Gulf, there was a strong correlation between research and commercial pot CPUE that would likely enable a simple transformation of the existing reference points. For GSV, however, an additional three to five years of data will likely be required to enable the relationship to be re-assessed or investigation of alternative statistical methods.

Finally, while updated recreational catch estimates were available from the 2021/22 State-wide survey (Beckmann et al. 2023), the large gap between State-wide surveys continues to be a challenge when assessing stock status. This could be addressed by undertaking more frequent recreational surveys or developing suitable proxies for recreational catch and effort, to provide estimates for the intervening years. The latter is currently being investigated as part of FRDC project 2020-056 "Evaluation of a smart-phone application to collect recreational fishing catch estimates, including an assessment against an independent probability-based survey, using South Australia as a case study." In addition, while the 2021/22 recreational fishing survey

provided relatively robust estimates of catch and harvest weight for the GSV, SG and WC zones, there was limited data available from the 2013/14 survey to analyse regional trends. This was largely due to the lower sample size for the 2013/14 survey, resulting in less robust estimates when attempting to disaggregate data (e.g. by region or platform). This highlights the need to ensure appropriate sample sizes in future surveys to investigate the underlying shifts in recreational catch which may inform stock assessment and fishery management.

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6. APPENDIX

APPENDIX 1

Advice Note Summary

- The latest FIS for the BCF were conducted in SG and GSV during March 2023.
- A total of 539 commercial pots and 60 research pots were sampled in SG, and 540 commercial pots and 59 research pots were sampled in GSV.
- For SG, the research pot CPUE of legal-size crabs was 7.3 ± 0.4 (SE) kg.potlift^{-1} in 2023. This was the highest recorded, above the target reference point, and equates to a TACC of 458.00 t.
- For GSV, the research pot CPUE of legal-size crabs was 2.3 ± 0.3 (SE) kg.potlift^{-1} in 2023. This was the lowest CPUE recorded for March/April, above the RP, and equates to a TACC of 245.15 t.
- A significant relationship was identified between research and commercial pot CPUE for SG. Re-calculation of reference points and decision rules for commercial pot CPUE resulted in no difference to the recommended TACC compared to using research pot CPUE for SG.
- While a significant relationship was identified between research and commercial pot CPUE for GSV, the proportion of the variance explained was low, therefore, re-calculation of reference points and decision rules for commercial pot CPUE was not presented.

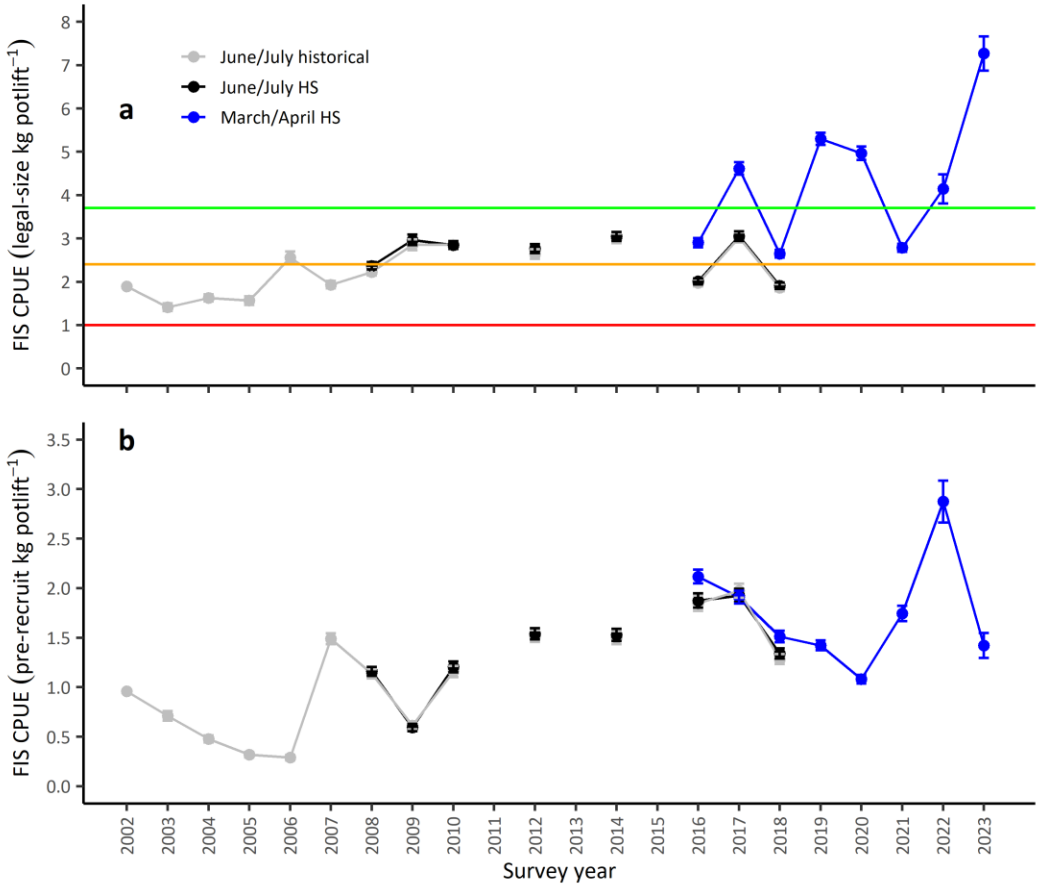
Summary of statistics for the March 2023 Gulf St. Vincent (GSV) and Spencer Gulf (SG) fishery-independent surveys (FISs) using research pots. SE, Standard error.

Gulf	Pot type	Potlifts	CPUE (legal-size crabs, kg.potlift^{-1})	Harvest strategy output
SG	Research	60	7.3 ± 0.4 (SE)	458.00 t
	Commercial	539	6.4 ± 0.1 (SE)	
GSV	Research	59	2.3 ± 0.3 (SE)	245.15 t
	Commercial	540	2.8 ± 0.1 (SE)	

Note- When legal-size CPUE is above 2.4 kg.potlift^{-1} (GSV) or 1.7 kg.potlift^{-1} (SG) TACC can increase by only one level per year

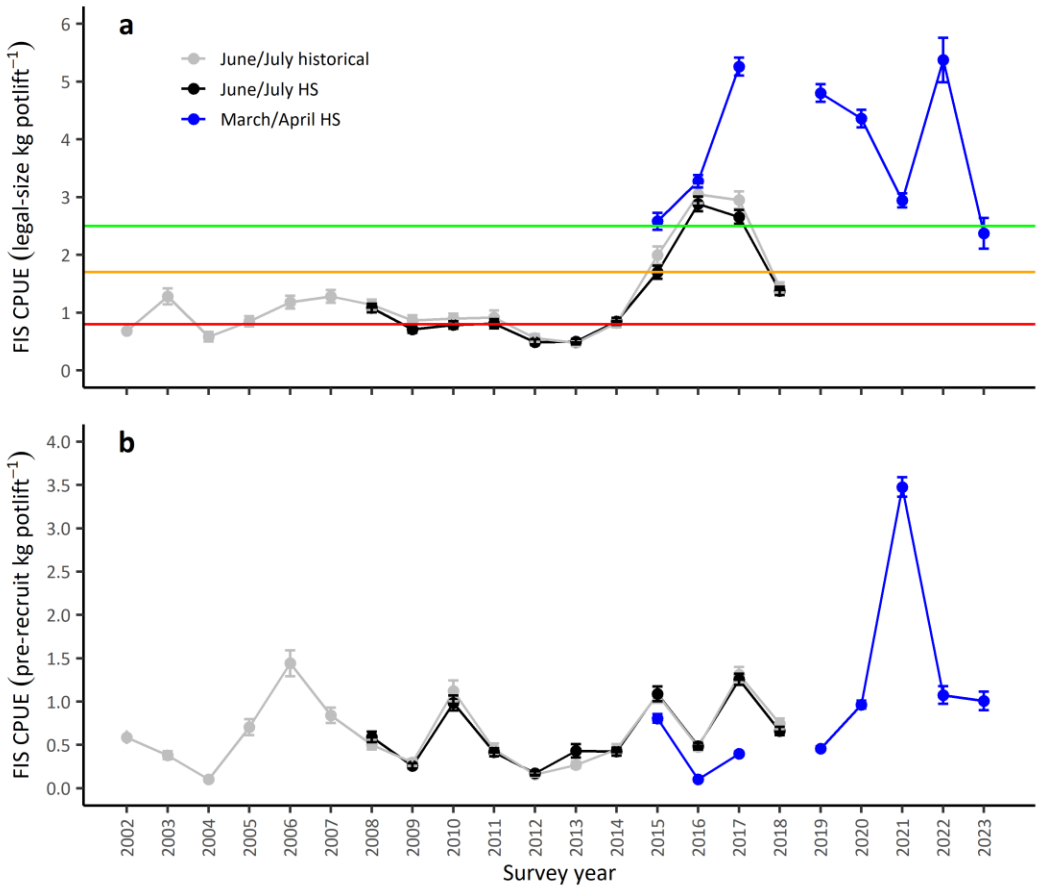
APPENDIX 1 (cont.)

Annual FIS CPUE from research pots in SG by weight of (a) legal-size crabs (kg.potlift^{-1}) from, 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 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 RPs for March/April identified in the HS. Error bars, standard error. Note. June/July FIS were not conducted in 2011, 2013, 2015, or from 2019.



APPENDIX 1 (cont.)

Annual FIS CPUE from research pots in GSV by weight of (a) legal-size crabs (kg.potlift^{-1}) from, and (b) pre-recruit crabs (kg.potlift^{-1}). Historical sites refer to 37 sites which have not changed since 2003 (excludes new sites) and 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 RPs for March/April identified in the HS. Error bars, standard error. Note: no FIS was conducted in March/April 2018 or from June/July 2019.



APPENDIX 2.

Key statistics for the Spencer Gulf Zone of the Blue Crab Fishery

Season	TACC	Catch (t)	Effort (potlifts)	Effort (days)	CPUE (kg.potlift^{-1})	CPUE (kg.boat	Mar/Apr FIS CPUE	Jun/Jul FIS CPUE
1983/84	-	5	NA	90	NA	30	NA	NA
1984/85	-	29	NA	527	NA	50	NA	NA
1985/86	-	113	NA	1201	NA	91	NA	NA
1986/87	-	126	NA	1141	NA	107	NA	NA
1987/88	-	146	NA	1113	NA	130	NA	NA
1988/89	-	240	NA	1071	NA	224	NA	NA
1989/90	-	264	NA	1079	NA	244	NA	NA
1990/91	-	288	NA	1170	NA	246	NA	NA
1991/92	-	300	NA	1206	NA	248	NA	NA
1992/93	-	305	NA	1243	NA	245	NA	NA
1993/94	-	305	NA	1365	NA	223	NA	NA
1994/95	-	336	NA	1256	NA	268	NA	NA
1995/96	-	367	NA	1317	NA	279	NA	NA
1996/97	325	297	NA	1264	NA	235	NA	NA
1997/98	328	287	102,039	1183	2.7	243	NA	NA
1998/99	361	324	122,729	1313	2.4	247	NA	NA
1999/00	378	327	114,946	1364	2.7	240	NA	NA
2000/01	381.7	334	113,897	1218	2.7	274	NA	NA
2001/02	381.7	340	99,305	1064	3.3	319	NA	NA
2002/03	381.7	340	129,337	1180	2.7	288	NA	NA
2003/04	381.7	375	137,848	1269	2.7	295	NA	NA
2004/05	381.7	381	130,660	1171	3.0	325	NA	NA
2005/06	381.7	378	134,774	1096	2.9	345	NA	NA
2006/07	381.7	378	132,667	903	2.9	418	NA	NA
2007/08	381.7	382	160,555	1050	2.4	364	NA	2.4
2008/09	381.7	381	147,666	895	2.6	426	NA	3.0
2009/10	381.7	381	139,340	762	2.7	499	NA	2.9
2010/11	381.7	382	103,866	663	3.8	576	NA	NA
2011/12	381.7	377	84,756	672	4.4	561	NA	2.8
2012/13	381.7	382	99,513	748	3.8	511	NA	NA
2013/14	381.7	380	93,492	709	4.0	536	NA	3.0
2014/15	381.7	380	104,832	779	3.6	488	NA	NA
2015/16	381.7	380	105,497	779	3.5	488	2.9	2.0
2016/17	381.7	382	100,038	763	3.7	501	4.6	3.1
2017/18	381.7	359	87,372	674	4.1	533	2.6	1.9
2018/19	381.7	371	96,084	703	3.9	528	5.3	NA
2019/20	381.7	380	90,325	666	4.2	571	5.0	NA
2020/21	419.8	418	100,422	740	4.1	564	2.8	NA
2021/22	381.7	326	86,329	680	3.7	480	4.1	NA

APPENDIX 2 (cont.)

Key statistics for the Gulf St. Vincent Zone of the Blue Crab Fishery

Season	TACC	Catch (t)	Effort (potlifts)	Effort (days)	CPUE (kg.potlift^{-}	CPUE (kg.boat	Mar/Apr FIS CPUE	Jun/Jul FIS CPUE
1983/84	-	22	NA	444	NA	35	NA	NA
1984/85	-	24	NA	435	NA	39	NA	NA
1985/86	-	27	NA	430	NA	49	NA	NA
1986/87	-	28	NA	544	NA	46	NA	NA
1987/88	-	37	NA	799	NA	42	NA	NA
1988/89	-	42	NA	551	NA	68	NA	NA
1989/90	-	92	NA	1002	NA	82	NA	NA
1990/91	-	137	NA	1139	NA	109	NA	NA
1991/92	-	115	NA	1201	NA	89	NA	NA
1992/93	-	204	NA	1630	NA	118	NA	NA
1993/94	-	239	NA	1999	NA	117	NA	NA
1994/95	-	265	NA	2109	NA	123	NA	NA
1995/96	-	285	NA	2114	NA	133	NA	NA
1996/97	325	165	NA	964	NA	169	NA	NA
1997/98	211	183	49,452	1088	2.6	167	NA	NA
1998/99	232	207	50,826	1076	2.9	192	NA	NA
1999/00	243	213	53,740	1027	2.9	206	NA	NA
2000/01	245.1	209	57,343	970	2.7	213	NA	NA
2001/02	245.1	194	54,137	898	2.8	216	NA	NA
2002/03	245.1	217	66,407	933	2.7	232	NA	NA
2003/04	245.1	223	64,056	845	3.0	263	NA	NA
2004/05	245.1	232	66,053	814	3.1	286	NA	NA
2005/06	245.1	241	75,508	735	3.0	328	NA	NA
2006/07	245.1	239	71,392	714	3.1	334	NA	NA
2007/08	245.1	243	71,368	628	3.3	386	NA	1.1
2008/09	245.1	223	65,796	471	3.3	473	NA	0.8
2009/10	245.1	159	66,435	454	2.4	349	NA	0.8
2010/11	245.1	209	66,416	446	3.2	469	NA	0.9
2011/12	245.1	234	73,085	478	3.4	490	NA	0.5
2012/13	245.1	129	56,373	315	2.3	409	NA	0.5
2013/14	196.1	191	47,677	404	3.9	472	NA	0.9
2014/15	196.1	196	56,264	492	3.3	399	2.6	1.8
2015/16	245.1	245	65,903	568	3.5	432	3.3	2.9
2016/17	245.1	246	61,133	466	3.9	527	5.3	2.8
2017/18	245.1	244	69,028	515	3.5	474	NA	1.4
2018/19	245.1	245	60,613	457	3.9	536	4.8	NA
2019/20	245.1	240	61,709	419	3.8	573	4.4	NA
2020/21	269.7	174	64,917	401	2.7	435	2.9	NA
2021/22	269.7	195	65,266	502	2.9	389	5.4	NA

APPENDIX 3.

Monthly Mean SST Anomalies for the SA Gulfs [134 141 -40 -34] created using the daily time series (since 1993- present) of IMOS L3SM-1d night-only SST (QL>=4). SST observations for each of the smaller map regions are converted to anomalies using the SSTAARS climatology then averaged spatially and over each month. Data was sourced from Australia's Integrated Marine Observing System (IMOS) – IMOS is enabled by the National Collaborative Research Infrastructure Strategy (NCRIS). It is operated by a consortium of institutions as an unincorporated joint venture, with the University of Tasmania as Lead Agent.