Fisheries

Blue Crab (*Portunus armatus*) Fishery 2020/21

C. L. Beckmann and G. E. Hooper

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July 2022

Fishery Assessment Report to PIRSA Fisheries and Aquaculture

Government of South Australia
Department of Primary Industries and Regions

SARDI
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 indicators (PIs), 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 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, i.e., legal-size catch per unit effort (CPUE) calculated from fishery-independent surveys (FIS; PIRSA 2020).

Spencer Gulf

In 2020/21, 417.5 t was harvested from SG, which represented 99.4% of the TACC (419.84 t). This was the highest catch in the history of the fishery. Estimates of commercial CPUE were the third highest on record for catch-per-potlift and catch-per-boat day. Data from the April 2021 FIS indicated that pre-recruit CPUE increased for the first time since March/April surveys commenced in 2016 and was the third highest recorded. The FIS CPUE of legal-size crabs decreased for the second consecutive year and was the third lowest recorded for March/April. In 2021, legal-size FIS CPUE in SG was 2.8 ± 0.1 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 2020/21, 174.3 t was harvested from GSV, which represented 65.0% of the TACC (269.66 t). This was the lowest catch reported since 1996/97 and was largely driven by below average catches from July to October. From 2020 to 2021, annual estimates of commercial CPUE declined for both catch-per-potlift and catch-per-boat day. Pre-recruits in the March 2021 FIS were the highest on record. The FIS CPUE of legal-size crabs was the second lowest value recorded for March/April but remained high compared to June/July estimates. In 2021, legal-size FIS CPUE in GSV was 3.0 ± 0.1 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 swimmer crab stock is classified as '**sustainable**' (Table E-1).

Table E-1. Status of South Australia's Blue Crab Fishery stocks from 2018/19 to 2020/21 assessed against reference points (RP) for legal-size CPUE measured during March/April FIS.

Management Zone	**RPs (legal-size CPUE kg.potlift^{-1})**			**FIS Legal-size CPUE (kg.potlift^{-1}) & stock status**		
	Limit	**Trigger**	**Target**	**2018/19**	**2019/20**	**2020/21**
Spencer Gulf	1.0	2.4	3.7	5.3 ± 0.2 (Sustainable)	5.0 ± 0.2 (Sustainable)	2.8 ± 0.1 (Sustainable)
Gulf St Vincent	0.8	1.7	2.5	4.8 ± 0.2 (Sustainable)	4.3 ± 0.1 (Sustainable)	3.0 ± 0.1 (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 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 2019/20 stock assessment report (Beckmann and Hooper 2021).

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 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 commercial Fishery valued at $9.0 million (gross value of production; GVP) in 2019/20 (Econsearch 2021).

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 BCF (SG and GSV zones) is provided via a BCF or an 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 for Blue Crabs is confined to the WC, therefore it is considered separately from 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 endorsed licence holders 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 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.

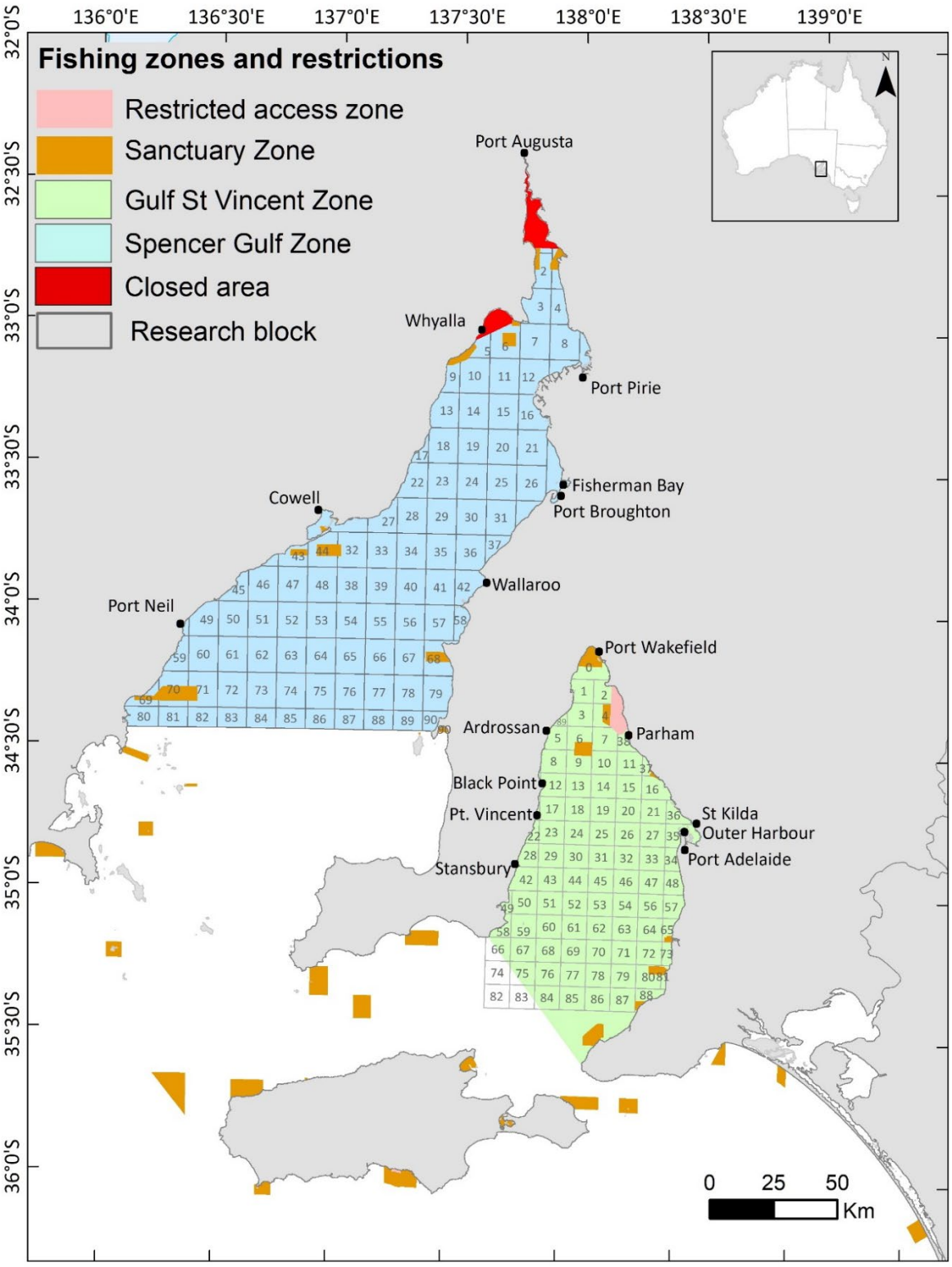

Figure 1.1 The South Australian Blue Crab Fishery with Spencer Gulf and Gulf St. Vincent fishing zones, research blocks and restrictions including closed areas, restricted access and Sanctuary Zones.

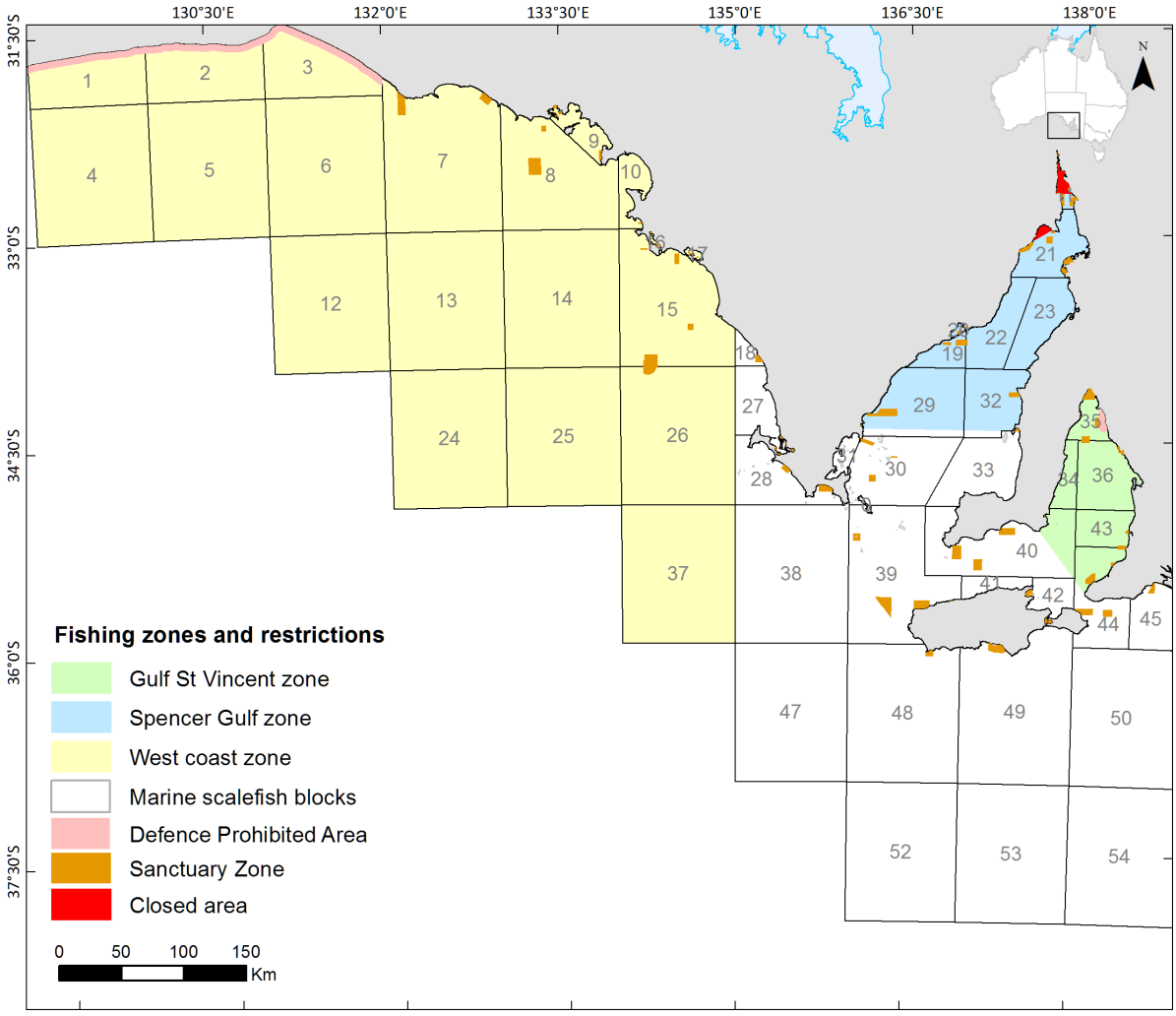

Figure 1.2 South Australian Marine Scalefish Fishery areas, Blue Crab Fishery research blocks, and restrictions including closed areas, restricted access and Sanctuary Zones. The Gulf St. Vincent and Spencer Gulf zones are part of the Blue Crab Fishery, and the West Coast zone (not subject to total allowable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

1.3.2. Management arrangements

The BCF 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 are 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 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. In addition, an advice note is prepared annually to report on the FIS results. A summary of these results for 2022 are provided in the appendix.

1.6. Management Plan

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. 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 (*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 (Stewardson *et al.* 2018) 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 (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

Fishery-independent surveys (FIS) are conducted using commercial industry vessels, in combination with independent onboard 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 in both gulfs 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 (Figure 2.1). No survey was undertaken in GSV during March/April in 2018 due to the POMS outbreak.

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 2.2). 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 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.

Paired surveys were undertaken from 2015 in GSV and 2016 in SG to transition from June/July to March/April surveys. This transition involved reducing the number of sites sampled during the FIS to allow for PIs and associated RPs to be developed based on the March/April time series (PIRSA 2020). 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 2.2 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 pots were set and hauled daily. Since 2006/07, commercial pots have increased in size, and larger mesh and escape gaps have become common. 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. Historically, 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). 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, 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). Since June 2014, pots in GSV have been set along a single line (long line) at each FIS location with sets 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. The carapace widths (mm) of captured Blue Crabs were measured using Vernier calipers, and details of sex and condition (dead, soft, berried) were recorded.

From FIS data, nominal CPUE was calculated as the average weight of legal-size blue crabs per research potlift and the average weight of pre-recruit blue crabs per research potlift. 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. 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.

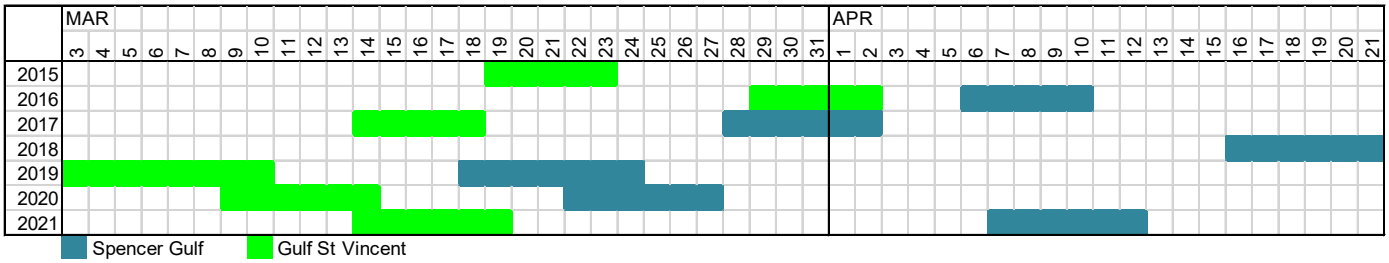

Figure 2.1 Fishery-independent survey (FIS) calendar for Spencer Gulf (SG) and Gulf St. Vincent (GSV) during March and April from 2015 to 2021.

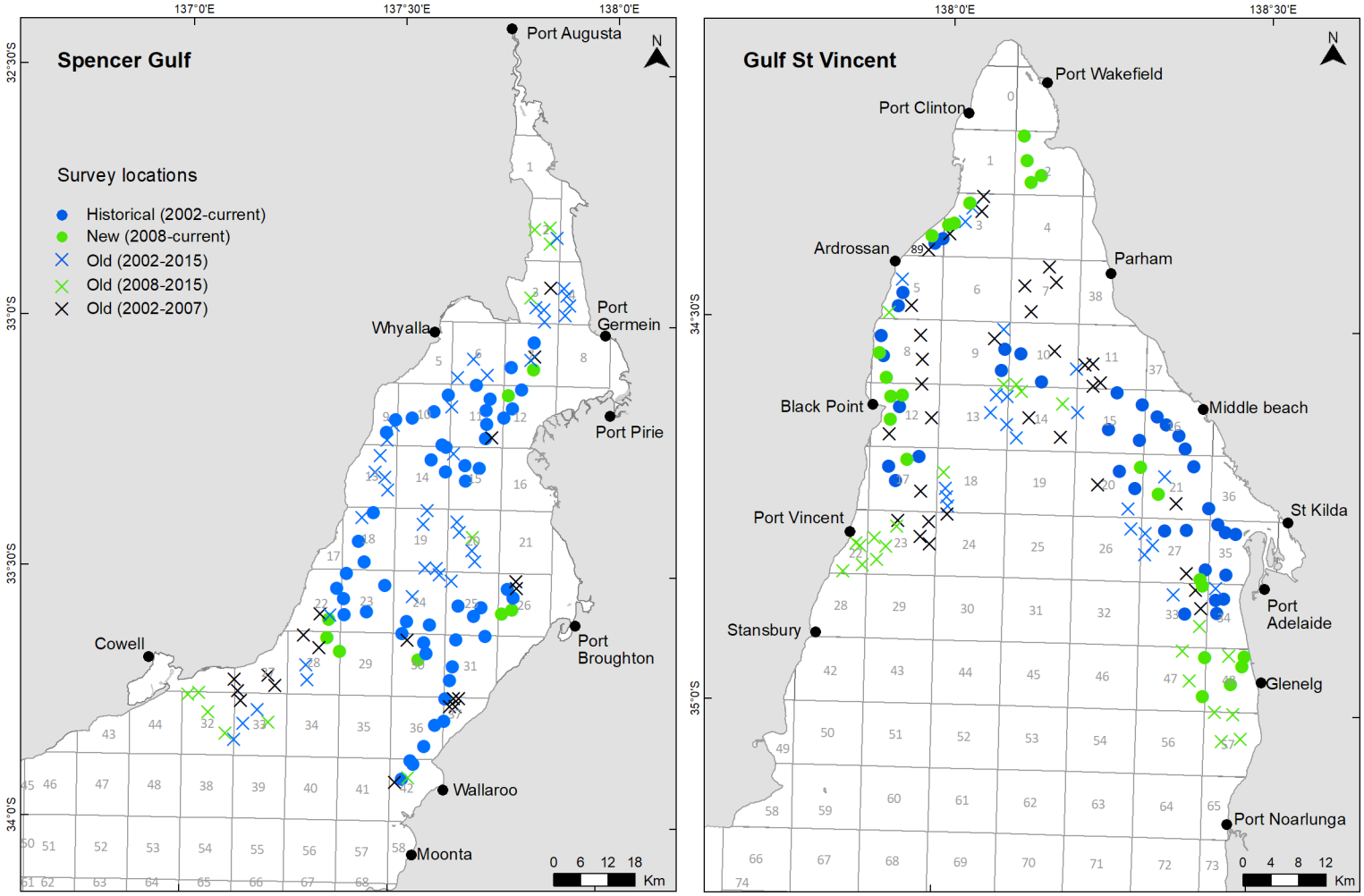

Figure 2.2 Commercial fishing blocks (grid) and fishery-independent survey (FIS) locations in the Spencer Gulf and Gulf St. Vincent zones of the Blue Crab Fishery. Circles represent the 60 sites chosen for the harvest strategy (historical sampled since 2002 in blue, new sampled since 2008 in green), 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.

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 6.2.

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 four 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) and 2013/14 (Giri and Hall 2015). 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 four published 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 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 2020/21, the State-wide catch was 665 t, which was above the previous 10-year average (642 ± 10 t [SE]).

3.1.2. Recreational

In the most recent recreational fishing survey, Giri and Hall (2015) reported that in 2013/14 there were 277,027 recreational fishers in South Australia and that Blue Crab was among the most caught species. In the 2013/14 survey period, recreational fishers harvested 1,423,794 (± 415,760 [SE]) crabs, equivelent to 376 t (Giri and Hall 2015). The harvest was higher than the previous estimate of 283 t in 2007/08 (Jones 2009), but lower than the estimate of 390 t in 2000/01 (Henry and Lyle 2003). During 2013/14, blue crabs were mostly harvested from SG, followed by the GSV and Kangaroo Island region (Giri and Hall 2015). The 2014 on-site (creel) survey estimate of Blue Crab catch from northern GSV was 245,000 (± 57,000 [SE]) crabs equivelent to 65 t harvested (Giri and Hall 2015). This was inline with the telephone/diary survey estimate of 67 t harvested in regions 16, 17 and 18 during 2013/14 (Giri and Hall 2015).

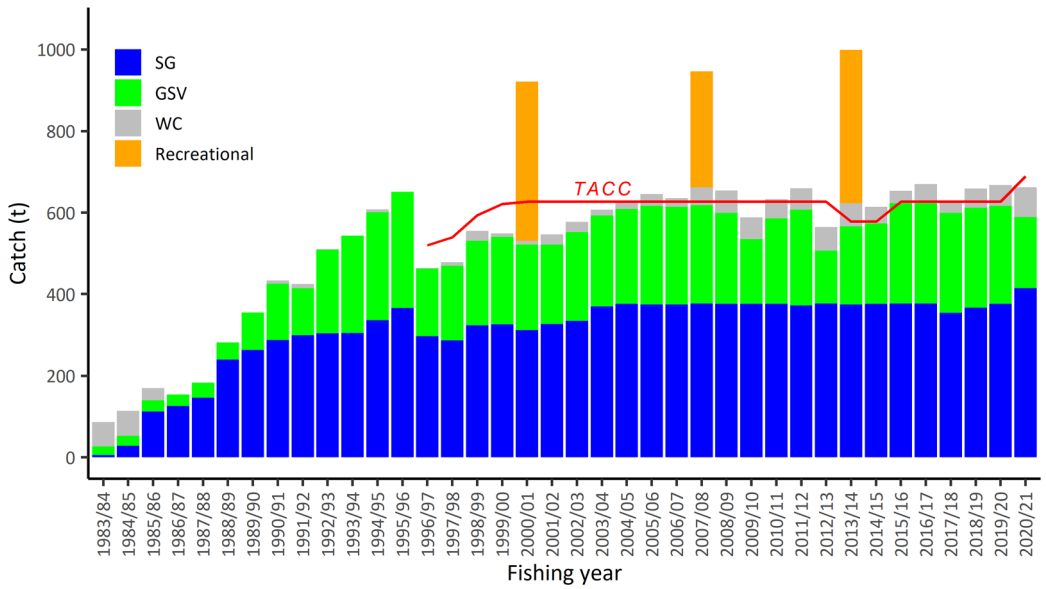

Figure 3.1 Commercial catch (t) of Blue Crabs from 1983/84 to 2020/21 in Spencer Gulf (SG); Gulf St. Vincent (GSV) and from the West Coast (WC). State-wide recreational catch (t) was estimated in 2000/01, 2007/08 and 2013/14.

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. 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 then declined in the following two years in response to the introduction of the annual TACC. From 2003/04 to 2016/17, >98% of the TACC was taken. During 2017/18, 94% of the TACC was taken and 97% of the TACC was harvested in 2018/19. In 2019/20, the catch was 380 t which represented 99.6% of the annual TACC (381.67 t). In 2020/21, the catch was the highest on record at 418 t, which represented 99.4% of the annual TACC (419.84 t).

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 was 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 stable since (mean: 735 ± 18 [SE] boat days). In 2020/21, 740 boat days were fished, which was an 11% increase compared to 2019/20 (666 boat days) and was above the previous 10-year mean (716 ± 15 [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 2020/21, the total number of potlifts per year has remained stable (mean: 96,233 ± 2,249 [SE]). In 2020/21, a total of 100,422 potlifts were recorded, which was the ninth 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 7,529 in 2011/12 and 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 (range: 15–135) were recorded in 2018/19 and 2019/20. In 2020/21, the number of second potlifts increased to 1,784.

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 2020/21, CPUE has

remained stable (mean: 528 ± 10 [SE] kg.boat day^{-1}). In 2020/21 CPUE was 564 kg.boat day^{-1}, which was the third 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: 3.6–4.4 kg.potlift^{-1}). In 2020/21, CPUE was 4.1 ± 0.1 (SE) kg.potlift^{-1}, which represented an 1% decrease from 2019/20 (4.2 ± 0.0 [SE] kg.potlift^{-1}) and was 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 17 in 1997/98 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, which was the lowest recorded since 2000/01 (20 blocks). In 2020/21, 26 blocks were fished.

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 near Port Broughton at Block 26 (>60 t) and near Wallaroo at Block 41 (>50 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 2020/21, the largest proportion of the catch was harvested between July and October (equivalent to 61% of the total annual catch) and in March (11% of the total catch). During November 2020, May 2021 and June 2021, catches were below the previous 5-year average.

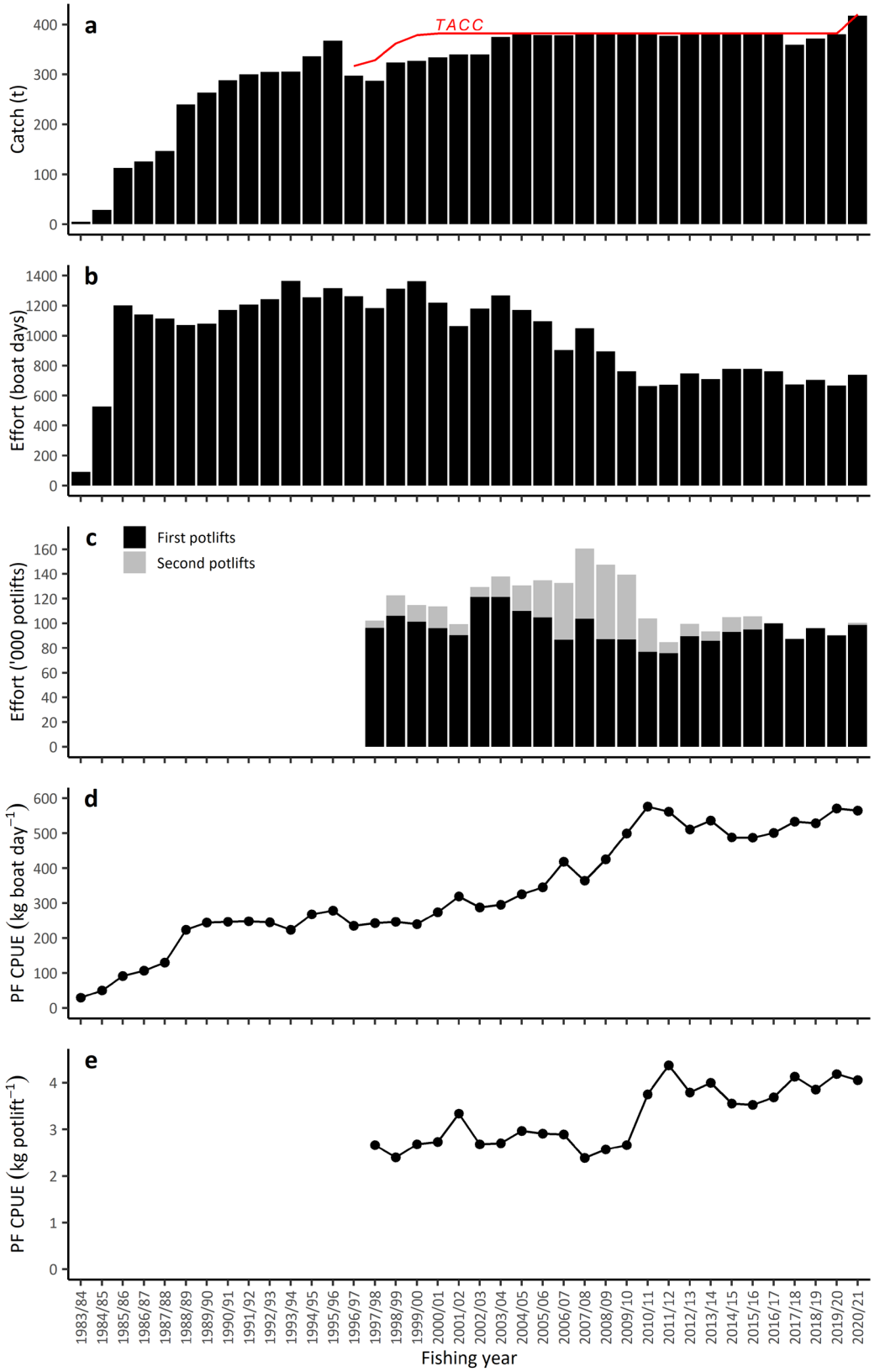

Figure 3.2 Fishery-dependent outputs for the Spencer Gulf zone of the Blue Crab Fishery. (a) Trends in total catch (t) including the total allowable commercial catch (TACC) limit; (b) targeted effort (boat days); (c) total effort from first and second potlifts by the BCF ('000 potlifts); (d) pot fishery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

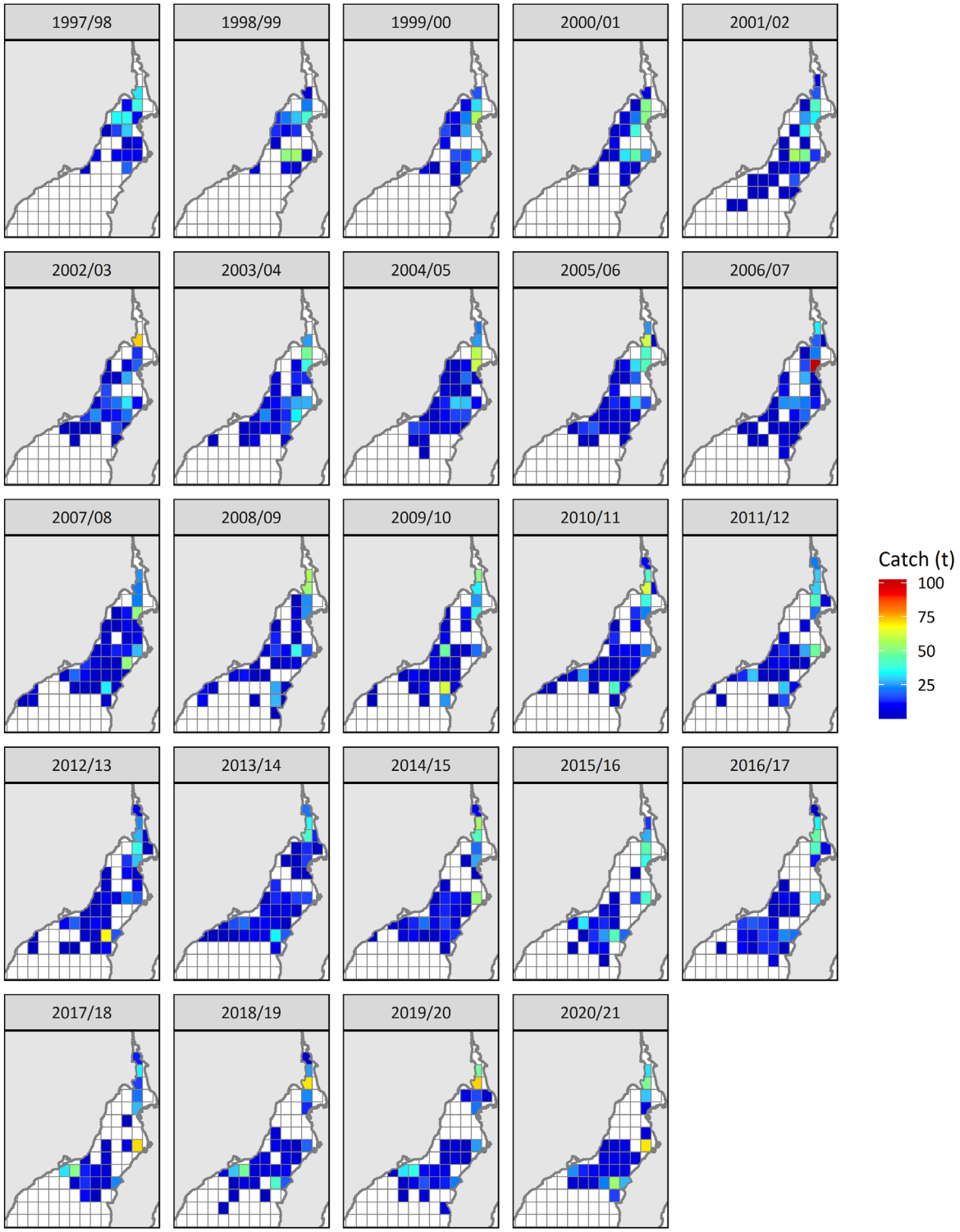

Figure 3.3 Commercial catch (t) reported by block for the Spencer Gulf Zone of the Blue Crab Fishery pot fishing sector from 1997/98 to 2020/21.

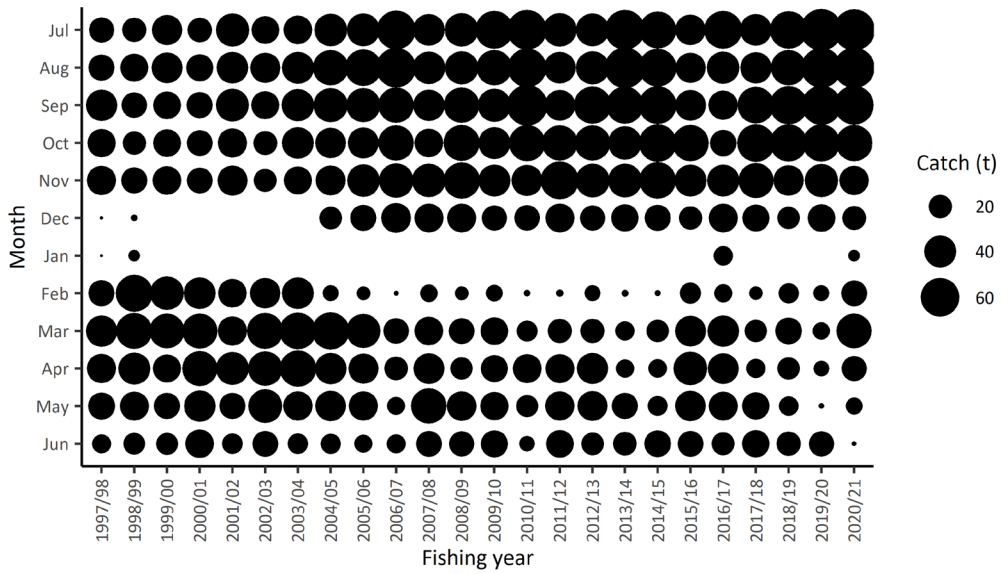

Figure 3.4 Monthly distribution of annual harvest (t) from the Spencer Gulf zone of the Blue Crab Fishery pot fishing sector during 1997/98 to 2020/21. Note: bubble area is proportional to monthly harvest.

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). 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}). 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 decreased by 44% from 5.0 ± [SE] 0.2 kg.potlift^{-1} in 2020 to 2.8 ± [SE] 0.1 kg.potlift^{-1} in 2021, which was the second lowest 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 (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}. 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 1.7 ± (SE) 0.1 kg.potlift^{-1} in March 2021, a 62% increase compared to March 2020 (1.1 ± [SE] 0.0 kg.potlift^{-1}) and the third highest recorded in March/April.

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). 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). In 2018 and 2019, pre-recruit density decreased throughout the gulf, with the highest densities observed adjacent to Port Broughton (Block 26). In 2020, pre-recruit density remained low with the highest densities observed south of Whyalla (Block 10). Pre-recruit density generally increased in 2021, with high densities observed near Wallaroo (Block 36) and Port Broughton (Blocks 26 and 30).

Legal-size crabs were generally concentrated in the northern SG, near Port Pirie and in the central gulf near Port Broughton. Low legal-size densities were observed throughout SG in 2016 and 2018, with somewhat higher densities observed adjacent to Port Broughton (Blocks 25, 30 and 31) in 2017. In 2019, high densities of legal-size crabs were also observed adjacent to Port Broughton (Block 24, 30 and 36). During 2019 and 2020, high densities of legal-size crabs were observed near Port Pirie (Block 7 and 12) and adjacent to Port Broughton (Blocks 26, 30 and 31). In 2021, the densities of legal-size crabs were generally low, except for the area near Port Pirie (Blocks 10, 11 and 15).

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 3.7). 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 2021, there was also a large proportion of undersize males ranging in size from 100–109 mm. Female crabs made up a low proportion (range: 4–17%) of the survey catch in all years. From 2016 to 2018 the modal size of female was below the legal size limit (mode: 105–109 mm), with increased female size observed during 2019 and 2020 (mode: 110-114 mm). In 2021, 13% of crabs were female and most were below the legal-size (mode: 100–104mm).

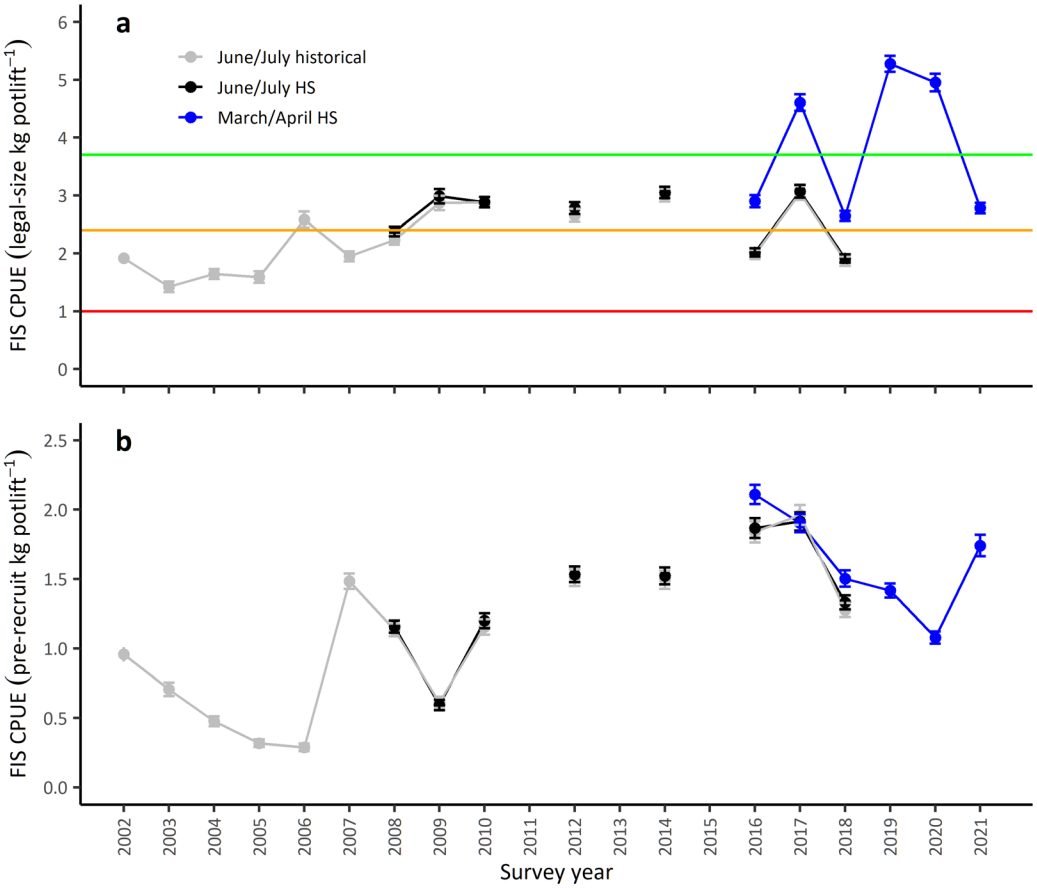

Figure 3.5 Key fishery-independent outputs used to assess the status of the Spencer Gulf zone of the Blue Crab Fishery (BCF). Fishery-independent (FIS) catch per unit effort (CPUE) by weight of (a) legal-size crabs (kg.potlift^{-1}), and (b) pre-recruit crabs (kg.potlift^{-1}). Historical sites refer 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, 2019–2021.

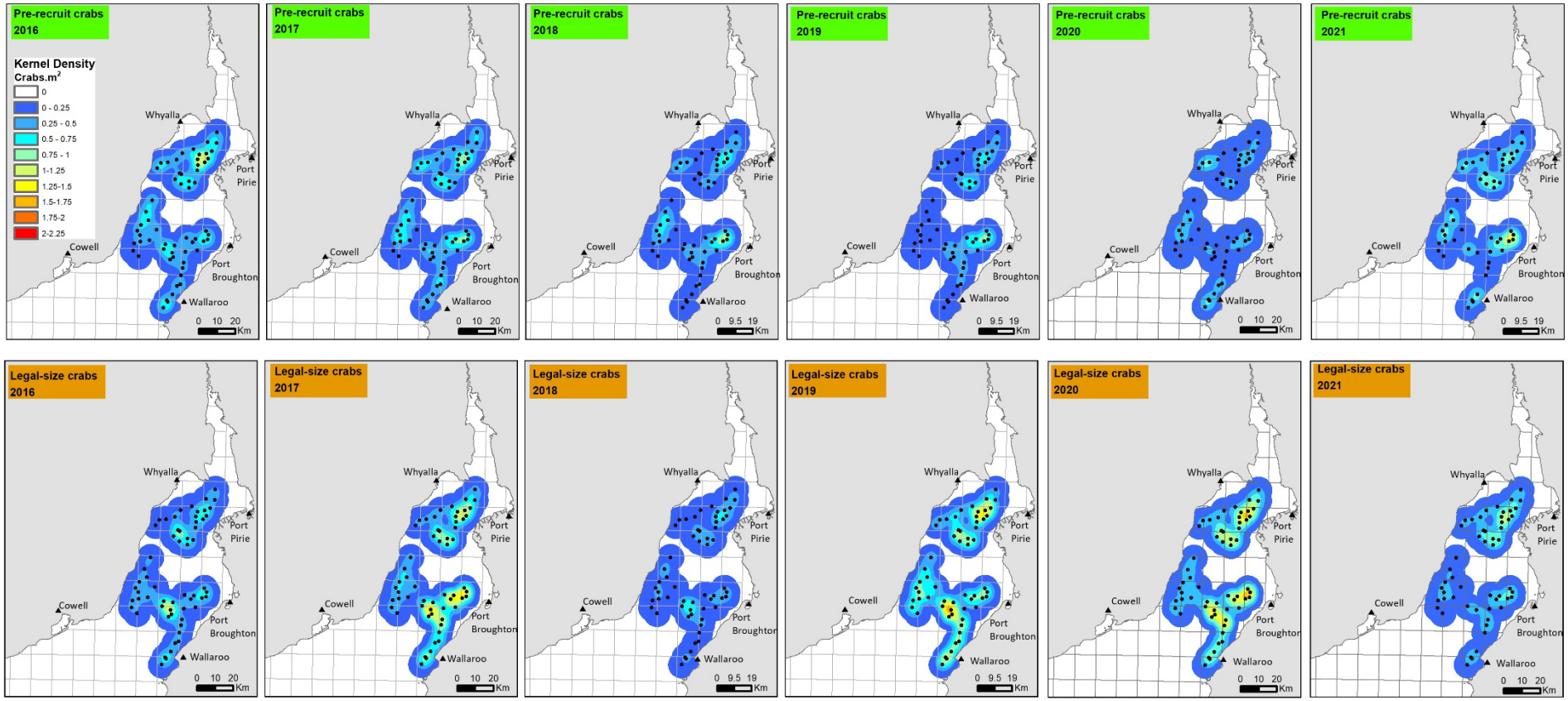

Figure 3.6 Relative density (crabs.m^{-1}) of pre-recruit (top panels) and legal-size (bottom panels) crabs from March/April fishery-independent surveys (FIS) in Spencer Gulf. Sampling locations denoted by ●.

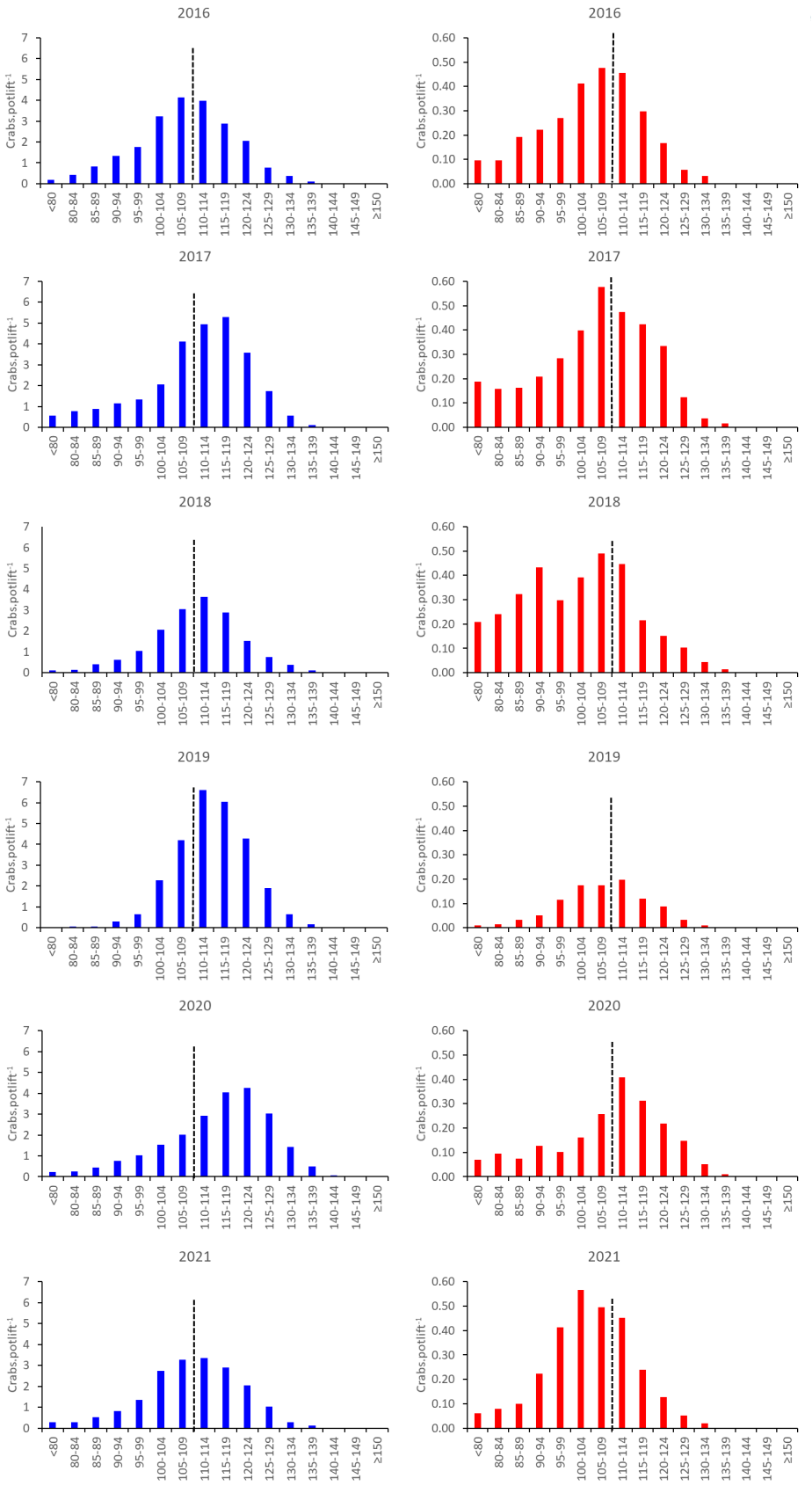

Figure 3.7 Length frequency distributions for male and female Blue Crabs from March/April fishery-independent surveys in Spencer Gulf, sampled at 60 sites selected under the harvest strategy from 2016 to 2021. Minimum size limit 110 mm carapace width, CW (---).

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 3.8a). 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, 174.3 t was harvested from GSV, which was equivalent to 65.0% of the TACC (269.7 t). This was the lowest catch reported since 1996/97 (162.5 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 3.8b). 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 2020/21, effort has been relatively stable (mean: 465 ± 21 [SE] boat days). In 2020/21, effort was 401 boat days, down from 419 boat days in 2019/20.

The number of 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, the number of total potlifts was relatively stable (mean: 69,082 ± 1,310 [SE] potlifts), before declining to a historical low of 47,677 in 2013/14. Between 2014/15 and 2020/21, the number of total potlifts remained stable (mean: 61,833 ± 2,310 [SE]). In 2020/21, the number of total potlifts was 66,541, which was up from 61,709 in 2019/20. 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 2019/20, the number of second potlifts was low (range: 0–219 potlifts). In 2020/21, there were 1,063 second potlifts, which was an increase from 140 in 2019/20.

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 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. In 2020/21 CPUE was 435 kg.boat day^{-1}, which was a 24% decrease compared to 2019/20 and the ninth 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 decreased by 33% from 3.9 ± 0.1 (SE) kg.potlift^{-1} in 2019/20 to 2.6 ± 0.1 (SE) kg.potlift^{-1} in 2020/21, which was the fourth 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 3.9). 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 3.9). 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 (≤ 22t) were reported across all blocks fished in 2020/21.

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 2015/16, peak

catches generally occurred during February or 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 and 2019/20, catches were evenly distributed from July to October and February to March. In 2020/21, the highest catches occurred in February and March. Catches were below the previous 5-year average during July–October and January–February, and no fishing was undertaken in July for the first time since 2013/14. Increased catches have been observed during November and December since 2015/16, with 32 t harvested during this period in 2020/21, up from 24 t in 2019/20.

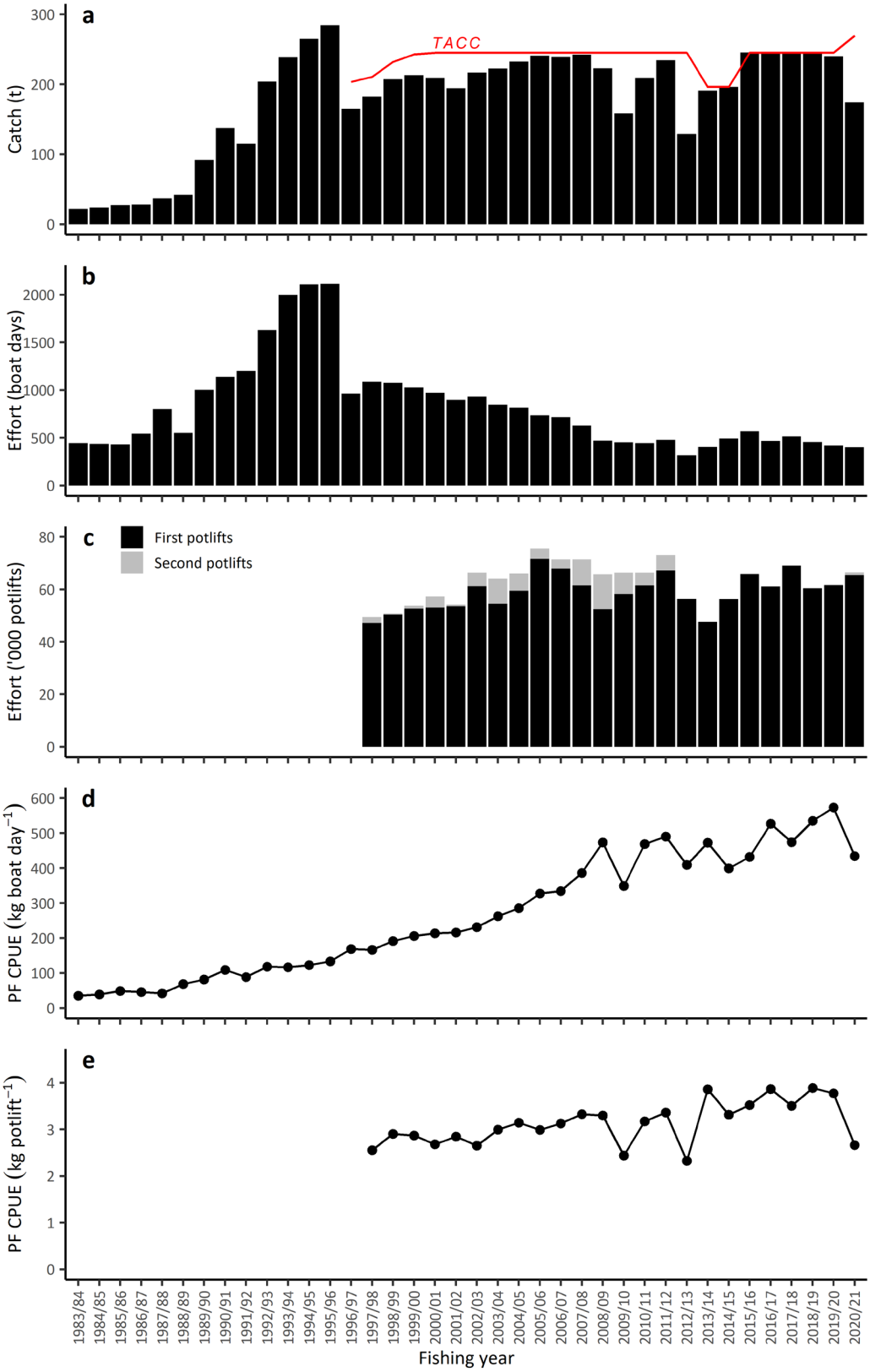

Figure 3.8 Fishery-dependent outputs for the Gulf St. Vincent zone of the Blue Crab Fishery; (a) trends in total catch (t) including the total allowable commercial catch (TACC) limit, (b) targeted effort (boat days), (c) total effort from first and second potlifts by the BCF, (d) pot fishery (PF) catch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

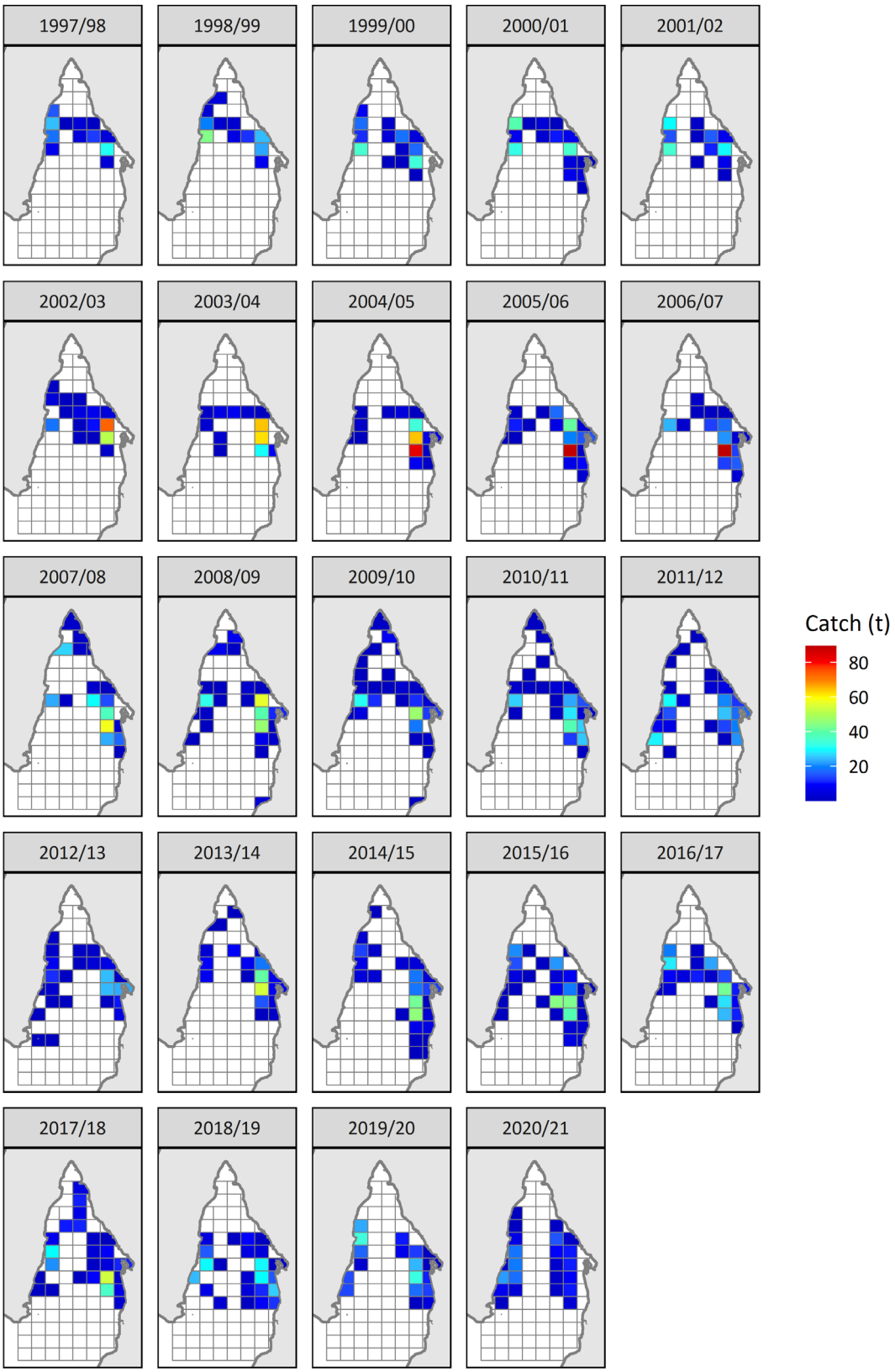

Figure 3.9 Commercial catch reported by block for the Gulf St. Vincent Zone of the Blue Crab fishery pot fishing sector from 1997/98 to 2020/21.

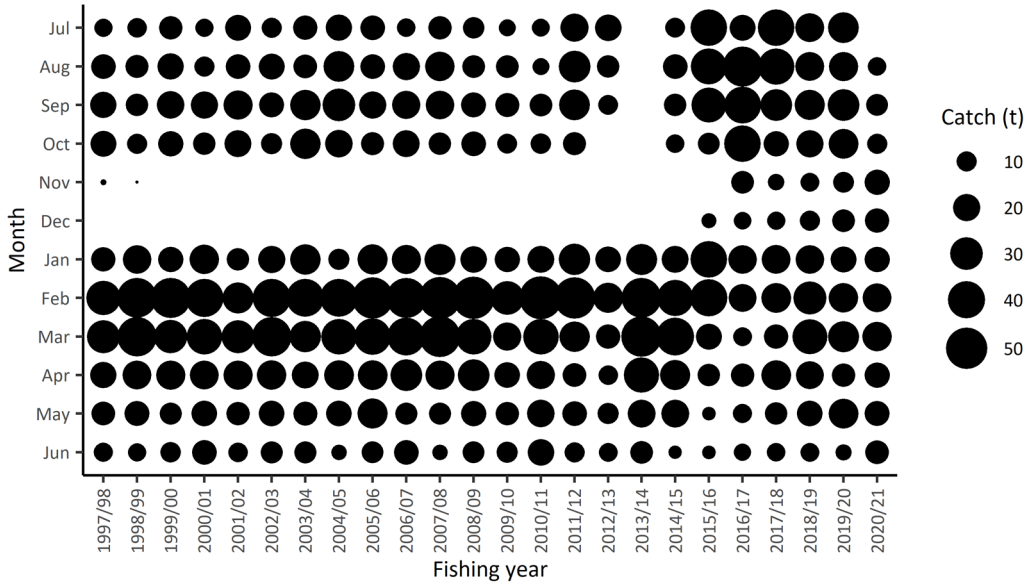

Figure 3.10 Monthly distribution of annual harvest from the Gulf St. Vincent zone of the Blue Crab Fishery pot fishing sector during 1997/98 to 2020/21. Note: bubble area is proportional to monthly harvest.

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). 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. 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. The March 2019 survey result was the second highest on record at 4.8 ± 0.2 (SE) kg.potlift^{-1}. The March/April survey CPUE decreased by 10% from 2019 to 2020, but remained the third highest value on record. In 2021, March/April survey CPUE was 2.9 ± 0.1 [SE] kg.potlift^{-1}, 32% lower than 2020 (4.4 ± 0.1 [SE] kg.potlift^{-1}), and the second lowest recorded for March/April.

The June/July CPUE of pre-recruits recorded by the FIS has 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}). 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. 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.

Density data 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 relatively high in 2015, particularly North of Port Adelaide (Blocks 20 and 35); adjacent to Ardrossan (Block 89), and near Black Point (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). In 2021, pre-recruit densities were increased adjacent to the metro coast (blocks 35, 47 and 48) and south of Ardrossan (Blocks 12 and 17). High densities of pre-recruits were observed throughout GSV in 2021, particularly near Port Adelaide (Blocks 21 and 27) and north of Port Adelaide (Blocks 15, 16, 20).

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, higher densities were observed adjacent to Ardrossan (Block 3 and 89) and off the Adelaide Metropolitan coastline (Blocks 33, 34 and 35). During 2020 and 2021, lower densities were observed near Ardrossan and off the Adelaide Metropolitan coastline when compared to the previous two surveys. 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) compared to 2018 but remained low compared to 2019.

Sex-specific length frequency data indicate that a high proportion of male crabs (range: 91–98%) were captured during March/April surveys (Figure 3.13). 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. During 2021, the catch was dominated by undersize males, with high catch rates observed for crabs in the 105–109 mm size class. 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 mmm) and 2021 (100–104 mm).

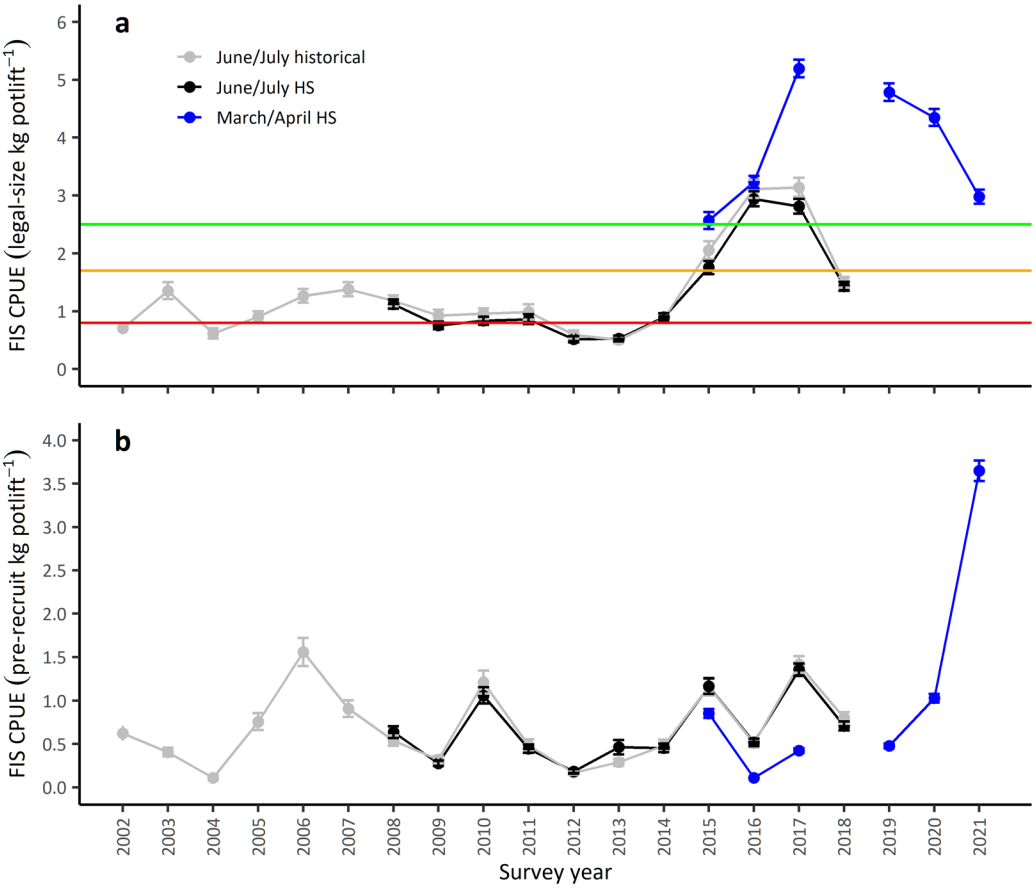

Figure 3.11 Key fishery-independent outputs used to assess the status of the Gulf St. Vincent zone of the Blue Crab Fishery (BCF). Fishery-independent (FIS) catch per unit effort (CPUE) by weight of (a) legal-size crabs (kg.potlift^{-1}), and (b) weight of pre-recruit crabs (kg.potlift^{-1}). Historical 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 harvest strategy (see Table 1.1). Error bars show ± SE. Note: no survey was conducted in March/April 2018 or June/July 2019–2021.

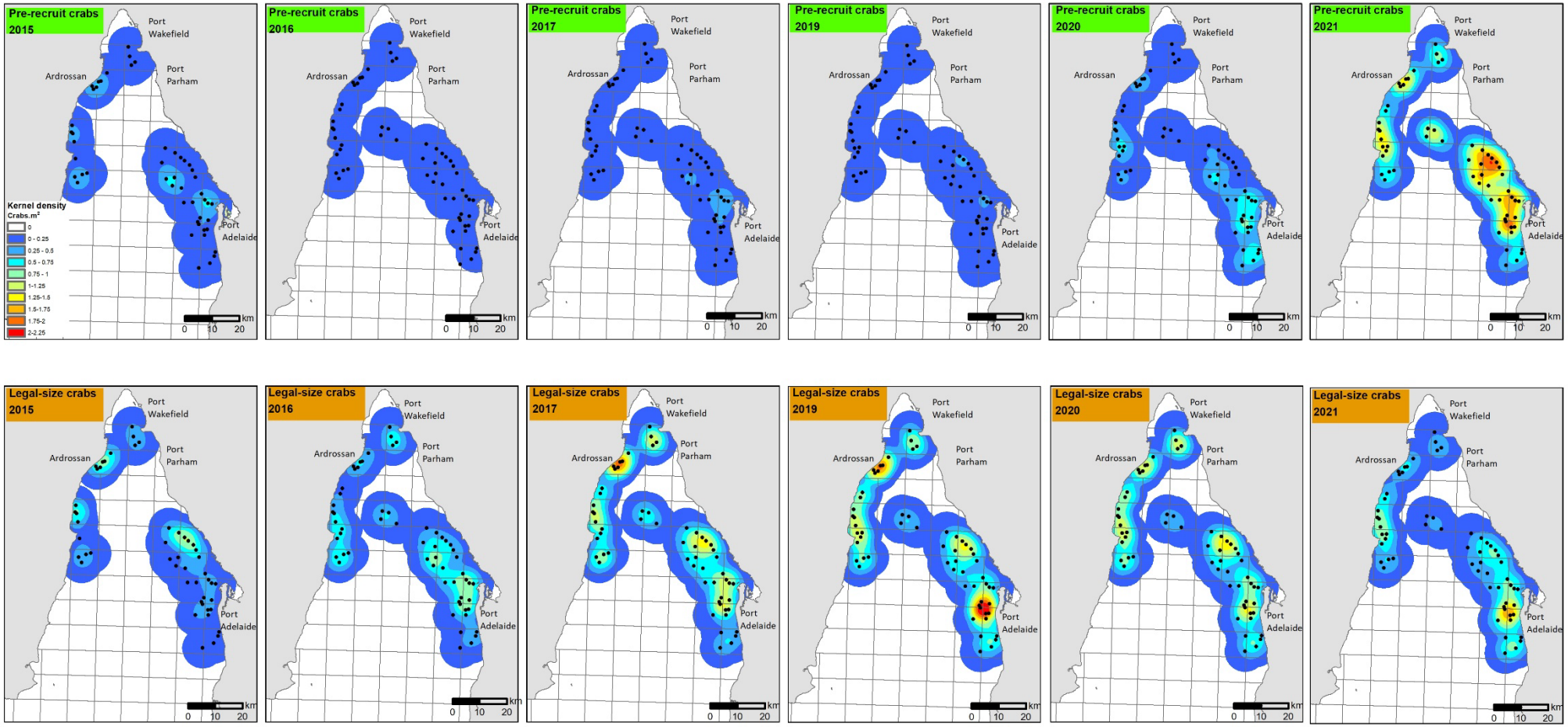

Figure 3.12 Relative density (crabs per square metre) of pre-recruit (top panels) and legal-size (bottom panels) crabs from March/April fishery-independent surveys (FIS) sampled in Gulf St. Vincent. Sampling locations denoted by ●. Note: no survey was conducted in March/April 2018.

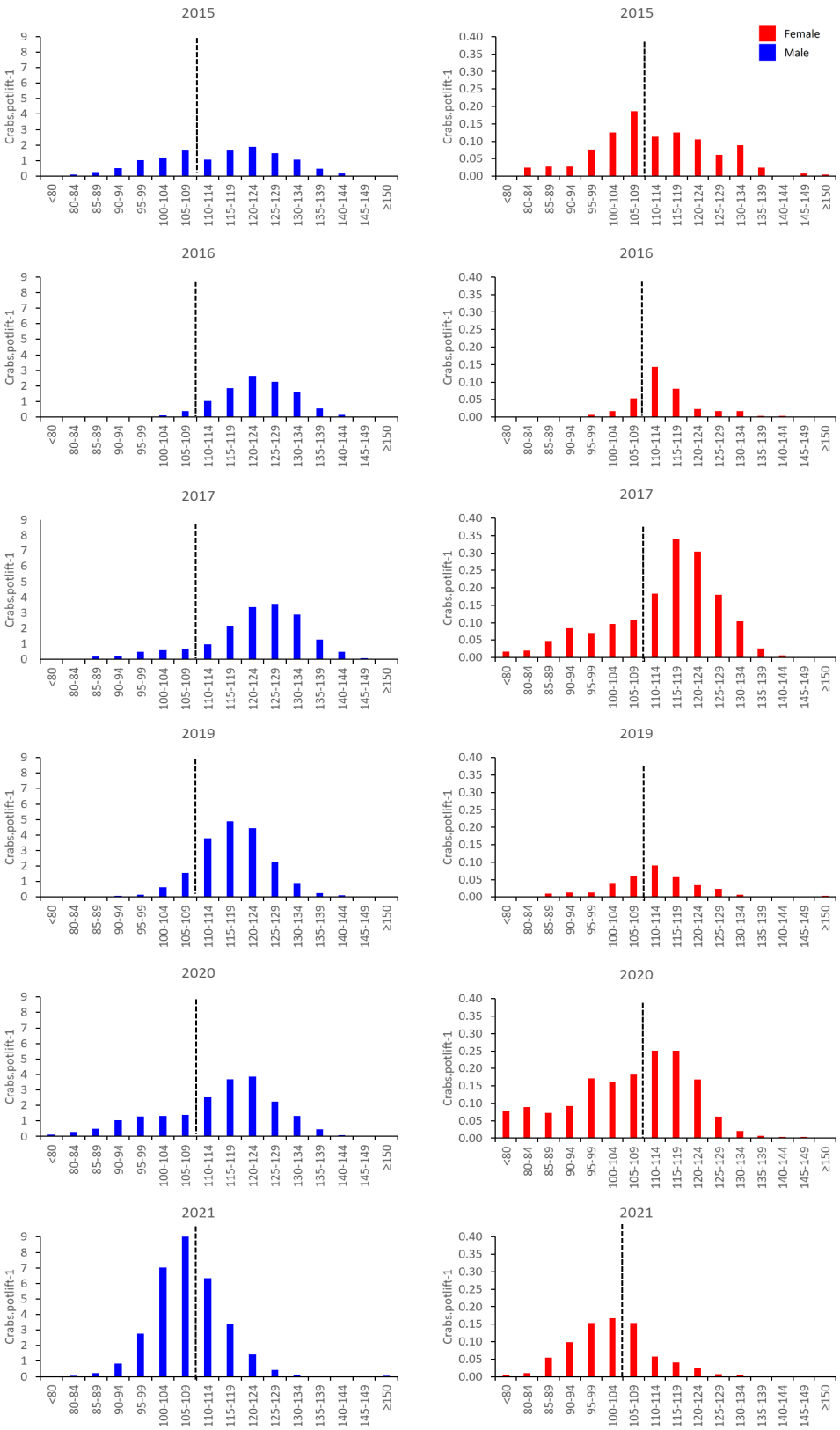

Figure 3.13 Length frequency distributions of male and female Blue Crabs from March/April fishery-independent surveys in Gulf St. Vincent sampled at 60 sites selected under the harvest strategy from 2015–2021. Minimum size limit 110 mm carapace width, CW (---). Note: no survey was conducted in March/April 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 Management Plan (PIRSA 2020). For SG, the CPUE of legal-size crabs in 2020/21 (2.8 kg.potlift^{-1}) was considerably lower than 2019/20 (5.0 kg.potlift^{-1}). This is below the target reference point (3.7 kg.potlift^{-1}), but remains above the trigger reference point (2.4 kg.potlift^{-1}) (Table 3.1). Similarly for GSV, the CPUE of legal-size crabs in 2020/21 (3.0 kg.potlift^{-1}) was lower than 2019/20 (4.3 kg.potlift^{-1}). Despite this, the CPUE remains above both 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 2016/17–2020/21. The key biological performance indicators (PIs) under the harvest strategy in the Management Plan are presented (PIRSA 2020).

Performance Indicator	Zone	Reference Point				Season				
		Limit	Trigger	Target		2016/17	2017/18	2018/19	2019/20	2020/21
March/April Legal-size CPUE (kg.potlift^{-1})	SG	1.0	2.4	3.7		4.6	2.6	5.3	5.0	2.8
	GSV	0.8	1.7	2.5		5.2	NA	4.8	4.3	3.0

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 fishery-dependent 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 2019/20, 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 under catches of 22 t and 10 t were observed, respectively. In 2020/21, the TACC was increased to 419.8 t, with 99.4% harvested, which resulted in the highest catch in the history of the SG zone. Overall, annual commercial catch, effort and CPUE has remained relatively stable for at least the past ten seasons.

The recent trends in FIS data reflect large fluctuations in legal-size CPUE, particularly since March/April surveys commenced in 2016. The 2021 legal-size CPUE was the second lowest recorded for March/April but remained high in a historical context. Trends in pre-recruit CPUE reflect high relative biomass, which peaked in 2016. A declining trend was observed until 2021 when pre-recruit CPUE increased and was the third highest reported.

In 2020/21, legal-size CPUE was 2.8 ± 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**'.

4.2.1. Gulf St. Vincent

From 2013/14 to 2019/20, the GSV zone of the BCF was classified as 'sustainable'. For 2013/14 and 2014/15, the TACC was set at 196.1 t and ≥ 97% was harvested. The TACC was increased to 245.1 t from 2015/16 to 2019/20 and during this period, ≥ 98% was harvested. In 2020/21, the TACC was increased further from 245 t to 269.7 t in accordance with the harvest strategy decision rules. The 2020/21 TACC was under-caught by 95 t and was the lowest catch since 2012/13. This was reflected by below average catches during July–October and January–February. While overall effort in terms of boat days was reduced, the number of potlifts remained relatively high. Overall, CPUE was the lowest observed since 2015/16 (catch-per-boat day) and 2012/13 (catch-per-potlift). Downward trends in commercial catch and effort may be partly explained by 1) the impact of COVID-19, 2) reduced operational capacity due to ship building delays, 3) La Niña conditions which persisted from October 2020 to March 2021 resulting in cold water anomalies during this period (Figure A5, IMOS 2022), and 4) high catch rates of small legal-size crabs which are not generally retained in large-mesh commercial pots.

The trends in FIS data reflect a period of high relative biomass since 2015. Legal-size CPUE increased to record-high levels in June/July 2016 and corresponding high levels were observed in March/April 2017. Since 2019, legal-size CPUE recorded in March/April has seen consecutive annual declines, but CPUE remains above historical levels. Pre-recruit CPUE has fluctuated through time with high values observed approximately every four or five years (i.e., in 2006, 2015, 2017 and 2021). In 2021, pre-recruit CPUE was the highest on record and more than double any of the previous estimates.

In GSV, the 2020/21 legal-size CPUE was 2.9 ± 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. Challenges and Uncertainties in the Assessment

Fishery-independent surveys have been identified as the most suitable data set to derive proxies for relative biomass to assess the stock status of Blue Crabs. This is because when compared to commercial fishing, the methods used to undertake surveys have remained relatively consistent through time, reducing the influence of external factors on CPUE. While the time-series for surveys extends back to 2002, gaps in the data set exist for the SG zone as bi-annual surveys were undertaken during 2010−2016. For the SG zone, large annual fluctuations in legal-size CPUE have been observed since 2016, and it's unclear whether similar trends existed between 2010 and 2016.

Interpretation of trends in FIS CPUE are further complicated by the transition from June/July to March/April surveys. To support this transition, paired surveys were undertaken in both zones to examine the relationships between the time series and re-calculate the performance indicators and associated reference points. Based on the available data for the SG zone, there is a strong relationship between June/July and March/April legal-size CPUE. Therefore, survey data was interpreted as following a similar trend regardless of timing, with legal-size CPUE generally higher during the March/April period. For the GSV zone, the relationship between March/April and June/July surveys undertaken in the same year was poor, largely due to high legal-size CPUE in March/April 2017 relative to the June/July survey. The relationship between the time series was somewhat improved when considering June/July surveys lagged (i.e., June/July 2020 with March/April 2021), however, large differences in CPUE values are still apparent. In addition, the March 2018 survey wasn't completed due to a Pacific Oyster Mortality Syndrome outbreak, creating a gap in the time series. As such, there is some potential for hyperstability when considering the March/April time series, in that CPUE may remain high during this period despite declining legal-size biomass.

While pre-recruit CPUE is no longer a primary performance indicator in the current HS, it can still provide valuable information about the future legal-size biomass. Research pots have smaller mesh and generally retain a high proportion of undersize crabs. Historically, it was thought that June/July was the key recruitment period for blue crabs. However, the 2021 survey result in GSV indicates that March/April can provide strong recruitment values in some years. Temporal data on recruitment was previously available from the voluntary pot sampling program, but this discontinued in 2019. As commercial pots don't retain many undersize crabs, research pot data from FIS is the only available data source.

The recreational sector's contribution to the State's total catch continues to be a significant knowledge gap when determining the overall status of Blue Crab stocks. This is highlighted by the most recent recreational harvest estimate which was 375.8 t during 2013/14. The 2021/22 recreational fishing survey, that concluded in February 2022, will provide an update on this estimate. The large gap between state-wide surveys continues to be a challenge when assessing the status of Blue Crab stocks. 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.

4.4. Future research needs

As global ocean temperatures are predicted to rise, it's important to consider the potential impacts of climate change on Blue Crab stocks and how they will respond. Previously, a biophysical model was developed to assess the effects of different environmental conditions on larval recruitment (McLeay et al. 2015). This model could be further developed by collecting information on the number of female crabs using a stratified survey design during the spawning period. Furthermore, additional research is required to identify size-specific maturity and spawning frequency. This type of model has the potential to identify areas with large contributions to egg production and larval settlement, and to assess the effects of different environmental conditions on larval recruitment.

Oceanographic modelling could also be used to understand predicted and observed changes in the distribution and abundance of Blue Crabs. As limited commercial fishing has occurred outside of the Blue Crab Fishery zones (other than on the West Coast), there is limited information available to assess changes to distribution and abundance. More information, either through fishery-dependent or fishery-independent sampling outside of the current fishing zones, would be required to assess population connectivity and evaluate any impacts on productivity and sustainability.

Finally, the 2021/22 research program included a project to assess, via a desktop study, the statistical differences in CPUE between the research and commercial pots used during FIS'. The outcomes of this study will be used to inform a harvest strategy review which will include updated reference points relative to FIS CPUE from commercial pots, and updated CPUE indices using the length-weight relationship developed from March/April FISs.

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6. APPENDIX

6.1 Advice Note Summary

- The latest fishery-independent surveys (FIS) for the Blue Crab Fishery (BCF) were conducted in Spencer Gulf (SG) and Gulf St Vincent (GSV) during March 2022.
- A total of 540 commercial pots and 59 research pots were sampled in GSV, and 535 commercial pots and 60 research pots were sampled in SG (Table A1).
- For GSV, the research pot catch per unit effort (CPUE) of legal-size crabs was 5.4 ± 0.4 kg.potlift^{-1} (standard error, SE) in 2022 (Figure A1). This was the highest recorded, above the target reference point (RP), and equates to a total allowable commercial catch (TACC) of 294.18 t (Table A1).
- No significant relationship was identified between research and commercial pot CPUE in GSV (Figure A2).
- For SG, the research pot CPUE of legal-size crabs was 4.1 ± 0.3 (SE) kg.potlift^{-1} in 2022 (Figure A3). This was the fourth highest recorded, above the target RP, and equates to a TACC of 419.84 t (Table A1).
- A significant relationship was identified between research and commercial pot CPUE in SG (Figure A4). Re-calculation of reference points and decision rules for commercial pot CPUE in SG resulted in no change to the outcomes determined based on research port CPUE (Table A1).

Table A1. Summary of statistics for the March 2022 Gulf St. Vincent (GSV) and Spencer Gulf (SG) fishery-independent surveys (FISs) using research pots. SE, Standard error.

Gulf	Pot type	Potlifts	CPUE (kg.potlift^{-1})	Harvest strategy output
GSV	Research	59	5.4 ± 0.4 (SE)	294.18 t
	Commercial	540	5.3 ± 0.1 (SE)	NA
SG	Research	60	4.1 ± 0.3 (SE)	419.84 t
	Commercial	535	4.7 ± 0.1 (SE)	419.84 t

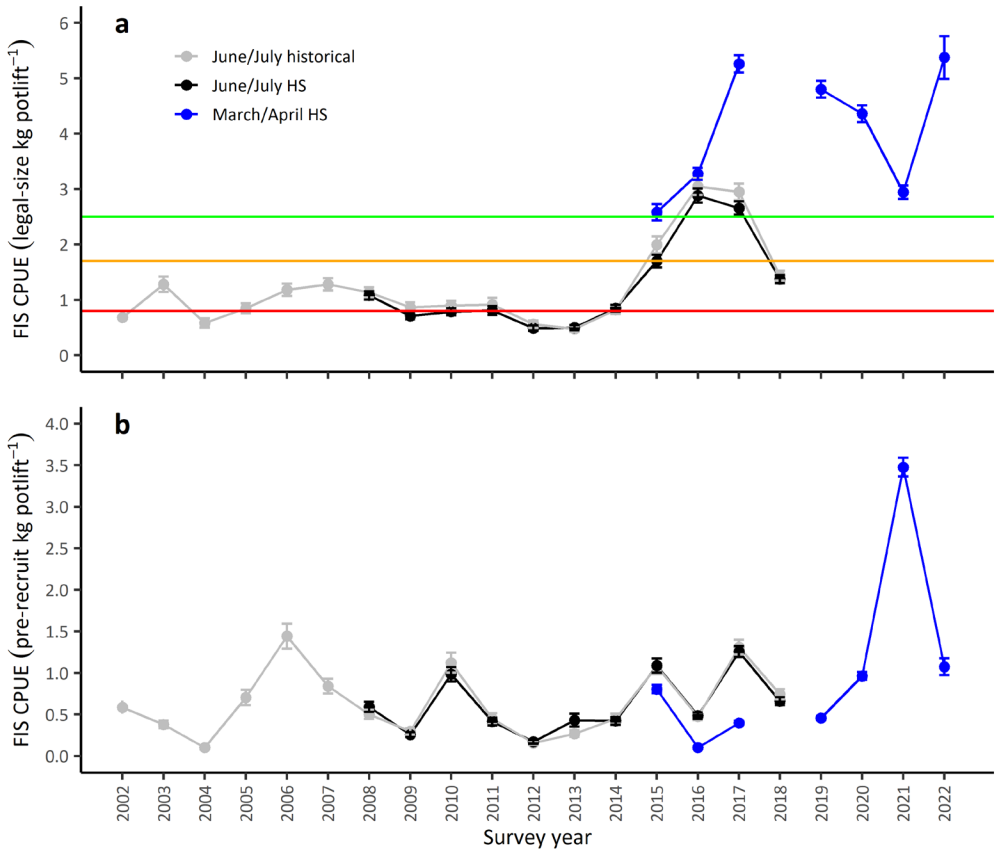

Figure A1. Fishery-independent (FIS) catch per unit effort (CPUE) by weight of (a) legal-size crabs (kg.potlift^{-1}), and (b) weight of pre-recruit crabs (kg.potlift^{-1}) for GSV. Historical sites refer to 37 sites which have not changed since 2003 (excludes new sites) and Harvest Strategy (HS) sites 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 FIS was conducted in March/April 2018 or from June/July 2019.

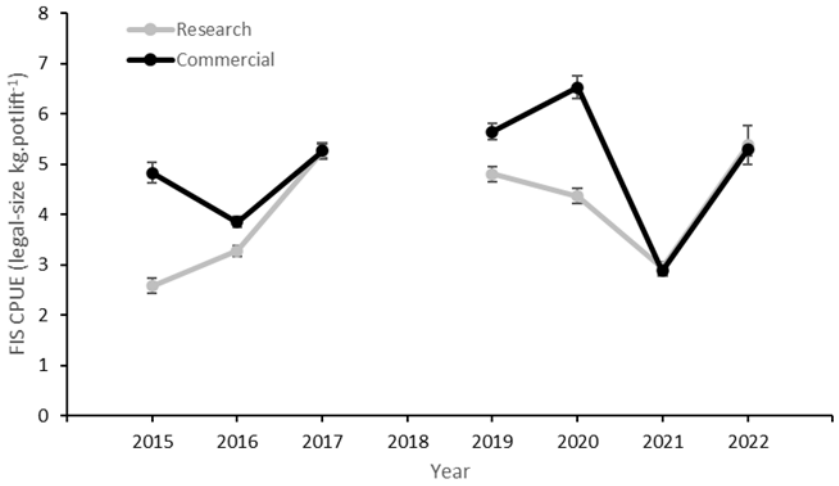

Figure A2. Annual commercial and research pot CPUE of legal-size crabs (kg.potlift^{-1}) from FIS undertaken during March/April in GSV. Error bars, standard error. Note: no FIS was conducted in 2018.

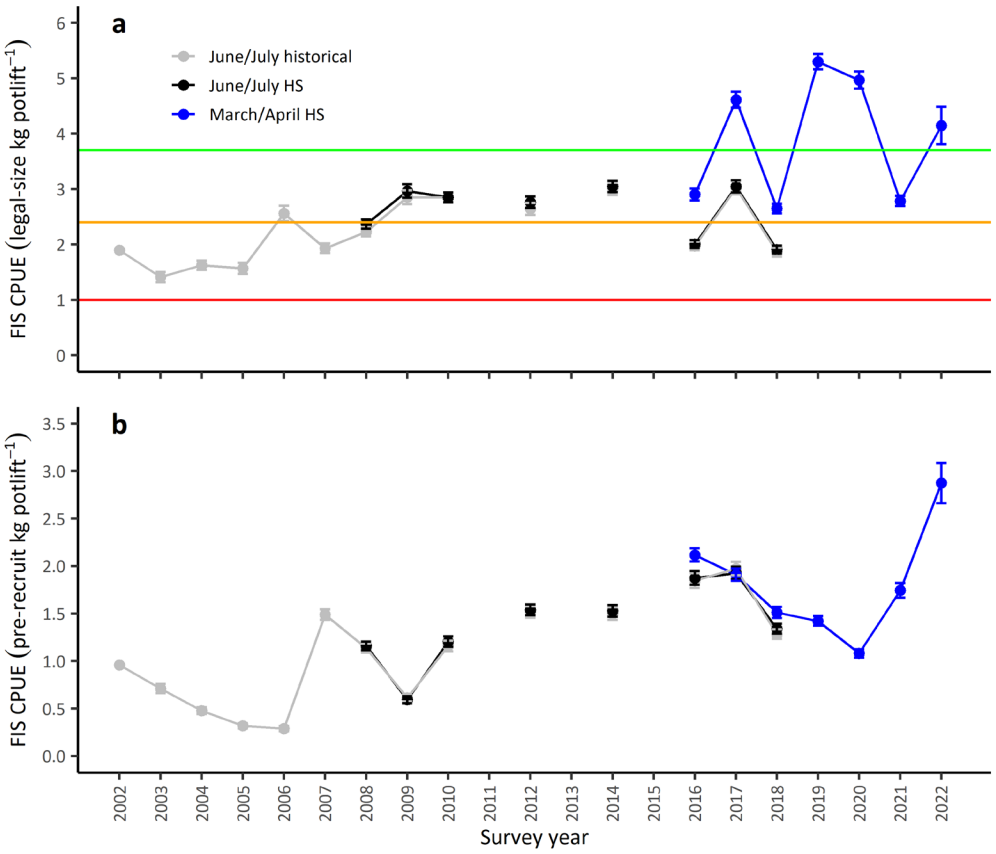

Figure A3. Fishery-independent (FIS) catch per unit effort (CPUE) by weight of (a) legal-size crabs (kg.potlift^{-1}), and (b) pre-recruit crabs (kg.potlift^{-1}) for SG. Historical sites refer to the 52 sites which have not changed since 2003 (excludes new sites) and Harvest Strategy (HS) sites refer 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, standard error. Note. June/July FIS were not conducted in 2011, 2013, 2015, or from 2019.

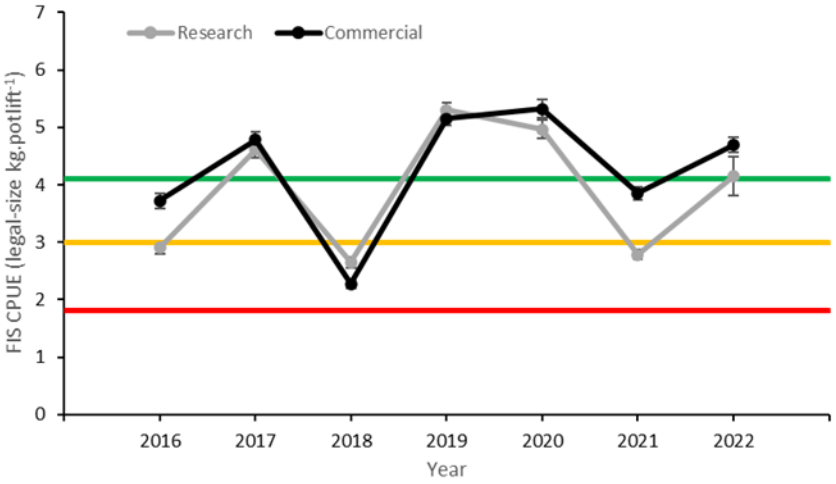

Figure A4. Annual commercial and research pot CPUE of legal-size crabs (kg.potlift^{-1}) from FIS undertaken during March/April in SG. Green, yellow, and red lines represent the target, trigger and limit RPs calculated from the linear relationship (Figure 8). Error bars, standard error.

6.2 Data Summaries

Table A2. Key statistics for the Spencer Gulf Zone of the Blue Crab Fishery

Season	Catch (t)	Effort (potlifts)	Effort (days)	CPUE (kg.potlift^{-1})	CPUE (kg.boat day^{-1})	Mar/Apr FIS CPUE (legal-size kg.potlift^{-1})	Jun/Jul FIS CPUE (legal-size kg.potlift^{-1})
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	297	NA	1264	NA	235	NA	NA
1997/98	287	102,039	1183	2.7	243	NA	NA
1998/99	324	122,729	1313	2.4	247	NA	NA
1999/00	327	114,946	1364	2.7	240	NA	NA
2000/01	334	113,897	1218	2.7	274	NA	NA
2001/02	340	99,305	1064	3.3	319	NA	NA
2002/03	340	129,337	1180	2.7	288	NA	NA
2003/04	375	137,848	1269	2.7	295	NA	NA
2004/05	381	130,660	1171	3.0	325	NA	NA
2005/06	378	134,774	1096	2.9	345	NA	NA
2006/07	378	132,667	903	2.9	418	NA	NA
2007/08	382	160,555	1050	2.4	364	NA	2.4
2008/09	381	147,666	895	2.6	426	NA	3.0
2009/10	381	139,340	762	2.7	499	NA	2.9
2010/11	382	103,866	663	3.8	576	NA	NA
2011/12	377	84,756	672	4.4	561	NA	2.8
2012/13	382	99,513	748	3.8	511	NA	NA
2013/14	380	93,492	709	4.0	536	NA	3.0
2014/15	380	104,832	779	3.6	488	NA	NA
2015/16	380	105,497	779	3.5	488	2.9	2.0
2016/17	382	100,038	763	3.7	501	4.6	3.1
2017/18	359	87,372	674	4.1	533	2.6	1.9
2018/19	371	96,084	703	3.9	528	5.3	NA
2019/20	380	90,325	666	4.2	571	5.0	NA
2020/21	418	100,422	740	4.1	564	2.8	NA

Table A3. Key statistics for the Gulf St. Vincent Zone of the Blue Crab Fishery

Season	Catch (t)	Effort (potlifts)	Effort (days)	CPUE (kg.potlift^{-1})	CPUE (kg.boat day^{-1})	Mar/Apr FIS CPUE (legal-size kg.potlift^{-1})	Jun/Jul FIS CPUE (legal-size kg.potlift^{-1})
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	165	NA	964	NA	169	NA	NA
1997/98	183	49,452	1088	2.6	167	NA	NA
1998/99	207	50,826	1076	2.9	192	NA	NA
1999/00	213	53,740	1027	2.9	206	NA	NA
2000/01	209	57,343	970	2.7	213	NA	NA
2001/02	194	54,137	898	2.8	216	NA	NA
2002/03	217	66,407	933	2.7	232	NA	NA
2003/04	223	64,056	845	3.0	263	NA	NA
2004/05	232	66,053	814	3.1	286	NA	NA
2005/06	241	75,508	735	3.0	328	NA	NA
2006/07	239	71,392	714	3.1	334	NA	NA
2007/08	243	71,368	628	3.3	386	NA	1.1
2008/09	223	65,796	471	3.3	473	NA	0.8
2009/10	159	66,435	454	2.4	349	NA	0.8
2010/11	209	66,416	446	3.2	469	NA	0.9
2011/12	234	73,085	478	3.4	490	NA	0.5
2012/13	129	56,373	315	2.3	409	NA	0.5
2013/14	191	47,677	404	3.9	472	NA	0.9
2014/15	196	56,264	492	3.3	399	2.6	1.8
2015/16	245	65,903	568	3.5	432	3.2	2.9
2016/17	246	61,133	466	3.9	527	5.2	2.8
2017/18	244	69,028	515	3.5	474	NA	1.4
2018/19	245	60,613	457	3.9	536	4.8	NA
2019/20	240	61,709	419	3.8	573	4.3	NA
2020/21	174	66,541	401	2.7	435	3.0	NA

6.3 Environmental data

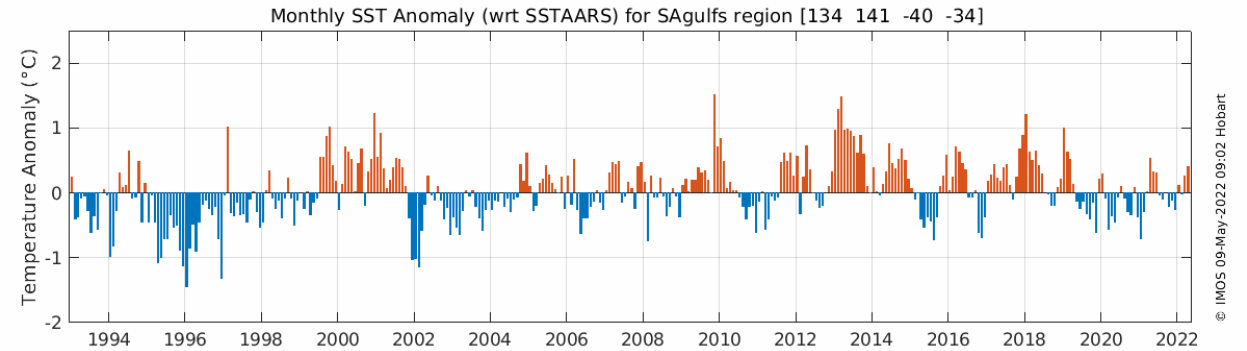

Figure A5. Monthly Mean SST Anomalies for the SA Gulfs [134 141 -40 -34] created using the daily time series (since 1993- present) of IMOS L3SM-1d night-only SST (QL>=4). SST observations for each of the smaller map regions are converted to anomalies using the SSTAARS climatology then averaged spatially 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.