

Fisheries

Gulf St Vincent Prawn *Penaeus (Melicertus) latisulcatus* Fishery 2022/23



L. J. McLeay and G. E. Hooper

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PO Box 120 Henley Beach SA 5022**

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Fishery Assessment Report to PIRSA Fisheries and Aquaculture

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EXECUTIVE SUMMARY

This report determines the status of the Western King Prawn (*Penaeus (Melicertus) latisulcatus*) stock in Gulf St Vincent (GSV) through analysis of data collected by several long-term monitoring programs. In 2022/23, the total commercial catch of Western King Prawn in the Gulf St Vincent Prawn Fishery (GSVPF) was 152.0 t, with an additional 4.8 t taken in fishery-independent surveys (FISs). Fishing was conducted over 319 vessel-nights, comprising 81% of the Total Allowable Commercial Effort (TACE) of 392 vessel-nights, which included 390 vessel-nights for the 2022/23 season and an additional 2 vessel-nights carried over from the 2020/21 season. A total of 83 vessel-nights were fished pre-Christmas (Table 1).

The Department of Primary Industries and Regions (PIRSA) has adopted the National Fishery Status Reporting Framework (NFSRF) to determine the status of all South Australian fish stocks. The management plan for the GSVPF provides the decision rules for classifying stock status relative to limit, trigger and target reference points defined for two performance indicators used as proxies of stock abundance (PIRSA 2022). The performance indicators are: 1) standardised fishery-independent survey (FIS) catch per unit effort (CPUE); and 2) standardised annual commercial CPUE.

Estimates of standardised FIS CPUE have remained above the target reference point (TargRP; 22.2 kg/rawl-shot) in 14 out of 18 years since 2004/05. Since 2018/19, standardised FIS CPUE has declined and was below the TargRP between 2020/21 and 2022/23. The 2022/23 estimate of 21.3 [17.0–26.4, 95% Confidence Intervals (CI)] kg/rawl-shot is the second lowest estimate on record but 15.1% above the trigger reference point (TrRP; 18.5 kg/rawl-shot). In 2022/23, the FIS Recruitment Index (FRI) was 383 ± 46 recruits.h⁻¹, which is approximately half the average FRI recorded since 2013/14 following the closure of the fishery.

In 2014/15, the estimate of standardised annual commercial CPUE was the highest on record at 1200 [1132–1272, 95% CI] kg/vessel-night. Estimates of standardised annual commercial CPUE then declined but remained between 43–56% above the TargRP of 738 kg/vessel-night between 2015/16 and 2019/20. In the last three seasons, standardised annual commercial CPUE was <15% above the TargRP. In 2022/23 standardised annual commercial CPUE was 832 [781–886, 95% CI] kg/vessel-night, which is a 4% increase since 2021/22 (799 [751–849 95% CI] kg/vessel-night) and 12.7% above the TargRP.

Decreasing trends in prawn size estimated from the FISs and commercial prawn-grade data since 2014/15 are indicative of changes in the stock size-structure of Western King Prawns in GSV and that prawns are now being harvested at a smaller average size than that which produces maximum yield per recruit. These trends, coupled with the historically low catches and estimates of FIS CPUE and standardised commercial CPUE in recent seasons, signal a recent period of stock decline and reduced fishery performance relative to when the fishery reopened

in 2014/15. Net economic return has also been negative between 2019/20 and 2021/22 (range: -\$0.4 million to -\$1.4 million; BDO EconSearch 2023).

Despite these trends, 2022/23 estimates of standardised FIS CPUE and standardised commercial CPUE are both above the TrRP for these performance indicators (PIRSA 2022). Consequently, when the two performance indicators are applied in the decision rules within the harvest strategy to determine the status of the Western King Prawn stock in GSV, the stock is classified as '**sustainable**'.

Table 1. Key Gulf St Vincent Prawn Fishery statistics between 2019/20 and 2022/23. Note, estimates of standardised annual commercial CPUE and standardised FIS CPUE will differ in each status report as data are updated within the Generalised Linear Model.

	2019/20	2020/21	2021/22	2022/23
Total allowable commercial effort (TACE)	250 nights (40 pre-Christmas)	273 nights (20 pre-Christmas)	290 nights (45 pre-Christmas)	390 nights (80 pre-Christmas)
Carryover (TACE)	-	-	22 nights	2 nights
Total commercial catch	132.3 t (+2.0 t from survey)	109.3 t (+2.2 t from survey)	138.5 t (+3.7 t from surveys)	152.0 t (+4.8 t from surveys)
Total effort	204 vessel nights (40 pre-Christmas) 1,984 hours	270 vessel nights (27 pre-Christmas) 2,603 hours	298 vessel nights (22 pre-Christmas) 3,123 hours	319 vessel nights (83 pre-Christmas) 3,020 hours
Standardised annual commercial CPUE	1055 kg/vessel-night	764 kg/vessel-night	799 kg/vessel-night	832 kg/vessel-night
Standardised FIS CPUE	23.8 kg/trawl-shot	21.2 kg/trawl-shot	21.7 kg/trawl-shot	21.3 kg/trawl-shot
FIS Recruitment Index (FRI)	597 recruits.h ⁻¹	801 recruits.h ⁻¹	1,186 recruits.h ⁻¹	383 recruits.h ⁻¹
Status	Sustainable	Sustainable	Sustainable	Sustainable

Keywords: Western King Prawn, *Penaeus (Melicertus) latisulcatus*, trawl fishery, Gulf St Vincent, South Australia.

1. INTRODUCTION

1.1. Overview

Stock assessments for the Gulf St Vincent Prawn Fishery (GSVPF) are part of the South Australian Research and Development Institute's (SARDI - Aquatic and Livestock Sciences) ongoing fisheries' assessment program. This report assesses the status of the Western King Prawn (*Penaeus (Melicertus) latisulcatus*) (Kishinouye 1896) stock in Gulf St Vincent (GSV) and includes new data from the 2022/23 fishing season.

The report has three objectives: 1) present information relating to the fishery and biology of Western King Prawn; 2) assess the 2022/23 status of the Western King Prawn stock resource in Gulf St Vincent; and 3) identify future directions for the research program.

1.2. Description of the fishery

1.2.1. Access

There are three commercial prawn fisheries in South Australia: Spencer Gulf Prawn Fishery (SGPF), West Coast Prawn Fishery (WCPF) and GSVPF. The SGPF is the largest prawn fishery in South Australia in terms of total catch and has 39 licences. The WCPF is the smallest of the prawn fisheries with three licences. There are currently 10 commercial fishing licences issued for the GSVPF.

All three prawn fisheries use demersal otter trawls to target Western King Prawn at night between sunset and sunrise (Figure 1). Trawls tow funnel-shaped nets along the sea floor and retain the catch in bags located at the end of the net (commonly referred to as codends) (Figure 2). Licence holders in the GSVPF are permitted to retain and sell two species of by-product harvested incidentally during prawn trawling: Balmain Bug (*Ibacus* spp.) and Southern Calamari (*Sepioteuthis australis*). A smaller penaeid (*Metapenaeopsis crassima*) is also permitted to be retained in South Australian waters but is of low commercial value.

The fishing season of the GSVPF occurs from 1 November to 31 October of the following year with a closure in January and February. Fishing during the season generally occurs between the last quarter and first quarter of the moon and is permitted in depths greater than 10 m north of the geodesic joining GSV, Investigator Strait and Backstairs Passage (PIRSA 2017). The GSVPF is divided into 121 spatial reporting blocks for research and management purposes (Figure 3). The major home ports for GSVPF vessels are Port Adelaide and North Haven.

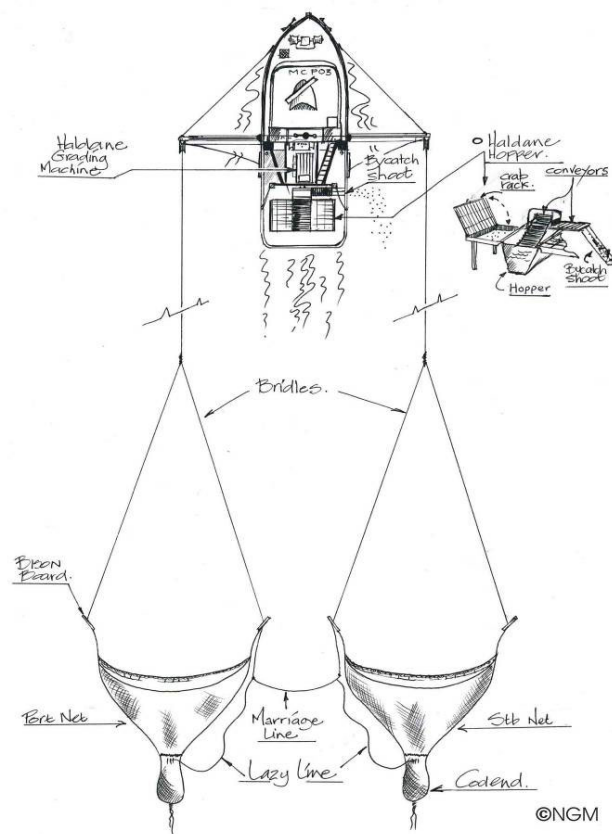


Figure 1. Double-rig trawl gear and location of hopper sorting and prawn grading systems used in the Gulf St Vincent Prawn Fishery. Figure from Carrick (2003).

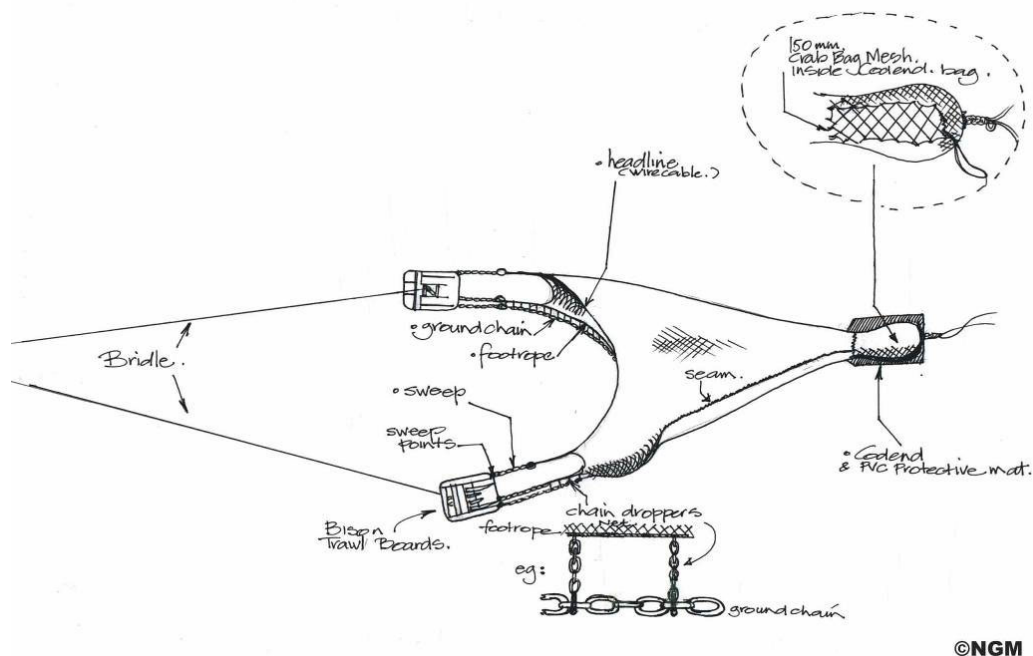


Figure 2. Trawl net configuration showing trawl boards, head rope, ground chain and codend with crab bag as used in the Gulf St Vincent Prawn Fishery. Figure from Carrick (2003).

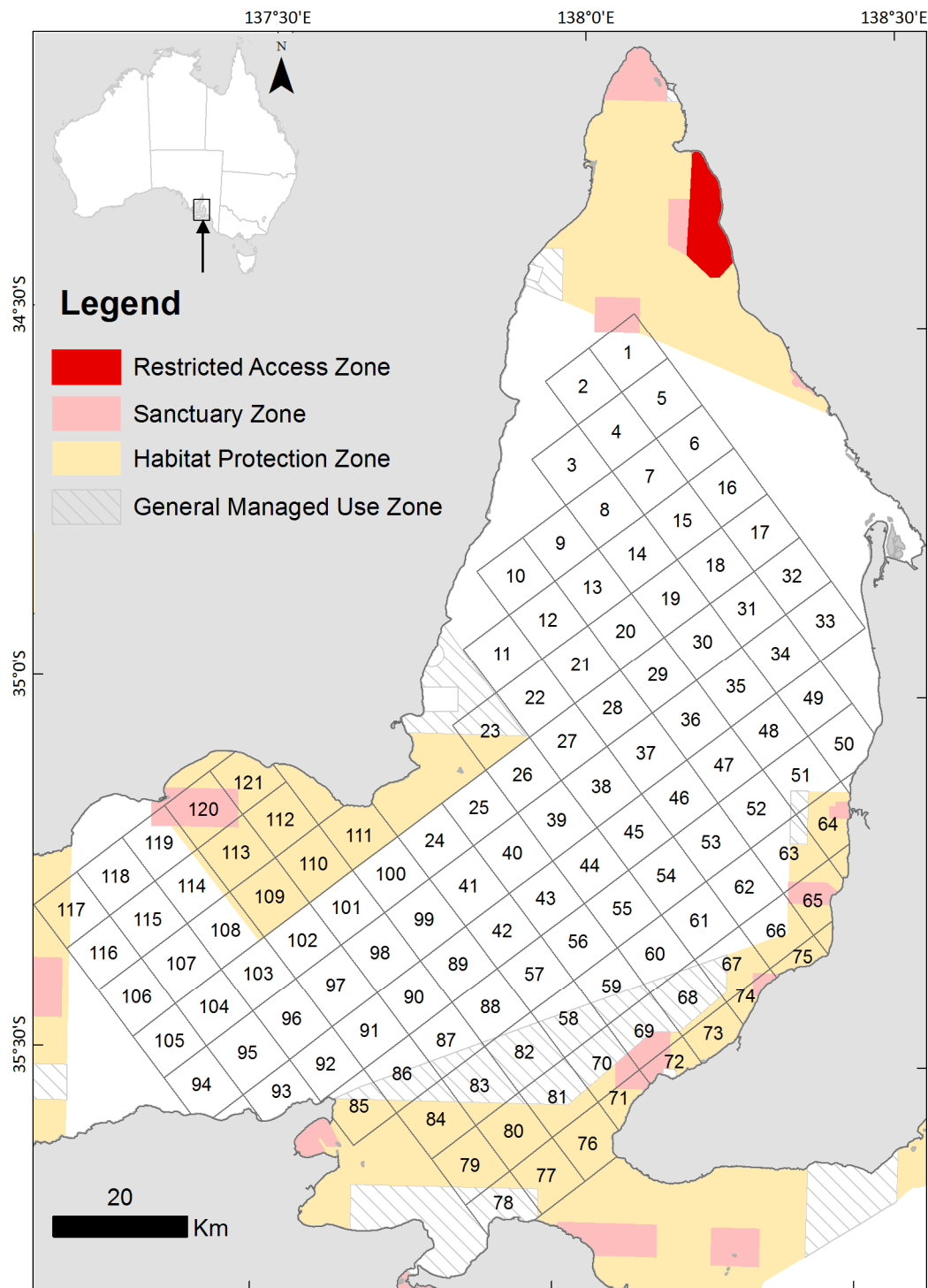


Figure 3. The spatial reporting blocks used in the Gulf St Vincent Prawn Fishery. South Australian Marine Park Zoning also shown.

1.2.2. Management arrangements

The *Fisheries Management Act 2007* provides the legislative framework for the management of fisheries resources in South Australia. General regulations for South Australia's prawn fisheries are described in the *Fisheries Management (General) Regulations 2017*, with specific regulations located in the *Fisheries Management (Prawn Fisheries) Regulations 2017*. These three documents provide the overarching statutory framework for management of the GSVPF.

Management arrangements for the GSVPF have evolved since the fishery's inception in 1967 (Table 2). Between 1967 and 1979, the number of licences increased to a total of 22 before being reduced to 10 by 1990. Following licence rationalisation in 1990, the Western King Prawn stock was considered overfished, and the fishery was closed during the 1991/92 and 1992/93 fishing seasons to allow recovery. The fishery reopened in 1993/94, and in 1998, the first management plan for the fishery was introduced. From 2004/05, four surveys per season were undertaken. A second management plan was implemented in 2007 (Dixon and Sloan 2007).

A review of the GSVPF in 2011 (Knuckey *et al.* 2011) recommended that the fleet improve its operating efficiencies. Two key management changes were subsequently implemented for the 2011/12 season: 1) the number of surveys used to manage the fishery during the fishing season was reduced to two (i.e. April and May); and 2) in March 2012, all trawl nets used for commercial fishing were modified to T90-mesh (conventional diamond mesh turned 90 degrees) codends and fitted with Nordmøre-grids to improve catch selectivity, reduce levels of bycatch and facilitate the escapement of small prawns (Dixon *et al.* 2013).

Due to poor economic performance, the fishery was closed again in 2012 at the request of licence holders. Following the fishery's closure in the 2012/13 and 2013/14 fishing seasons, a new management framework was developed with stakeholder input and implemented in November 2014 (PIRSA 2014). The management framework included an individual transferrable effort (ITE) system, with transferrable fishing nights as the effort unit. From 2013/14, the number of surveys was further reduced to one undertaken in May.

From 2014/15, control rules for spatial management, mean prawn size and mean nightly catches per vessel were adopted within the St Vincent Gulf Prawn Boat Owner's Association (SVGPBOA) Industry Code of Practice. The Industry Code of Practice is a non-legislated document that describes the expected activities for licence holders in the GSVPF. From 2014/15, a revised daily logbook, nightly fishing reports and individual

transferable units were also introduced (PIRSA 2022). The daily logbook requires licence holders to provide more detailed spatial information (start and end coordinates of each trawl-shot), and the nightly fishing reports provide a summary of the total catch unloaded per grade within 48 hours of unloading. Also, in November 2015, restrictions on the construction of the T90-mesh codend were modified so that no more than 33 meshes were made up of standard (diamond) mesh. Previously, between March 2012 and November 2015, no more than 10 meshes were allowed.

The third management plan for the fishery was implemented in April 2017, and stock status and Total Allowable Commercial Effort (TACE) for the fishery were determined from decision rules listed within the plan between 2016/17 and 2020/21 (PIRSA 2017). In 2021, a bio-economic model developed for the GSVPF in 2015 was updated with biological, catch and economic information, and used to inform development of a new harvest strategy for the GSVPF (Noell *et al.* 2015). The fourth management plan for the GSVPF implemented in July 2022 details the new harvest strategy and principal policy arrangements for management of the fishery (PIRSA 2022).

The current management arrangements for the fishery are summarised in Table 3. The GSVPF is currently a limited-entry (10 licence holders) fishery, which is managed by gear restrictions and a restriction on the number of fishing nights. Fishing takes place between sunset and sunrise. No trawling is permitted in waters shallower than 10 m. The harvest strategy listed within the management plan for the fishery uses decision rules for setting the total number of fishing nights (TACE) and number of pre-Christmas fishing nights each season (PIRSA 2022). The decision rules are based on limit, trigger and target reference points defined for two primary performance indicators relating to stock abundance:

- 1) standardised fishery-independent survey (FIS) CPUE, which is the average standardised CPUE from surveys conducted in March and April/May; and
- 2) standardised annual commercial catch per unit effort (CPUE);

These indicators are also used to determine the status of the Western King Prawn stock in GSV (see Section 1.6).

Table 2. Major management milestones for the Gulf St Vincent Prawn Fishery.

Date	Management Change
1967	Commercial prawn fishing commenced in GSV.
1968	All SA waters closed to trawling except for specific managed zones for which permits are offered and all waters less than ten metres are closed to trawling.
1969	The <i>Preservation of Prawn Resources Regulations 1969</i> is introduced and vessels licensed to fish for prawns.
1975	The fishery is split into two zones: 1) Gulf Saint Vincent; and 2) Investigator Strait with eight permits issued to specifically fish in Investigator Strait (Copes 1990).
1977	Total number of licences issued in Gulf Saint Vincent reaches 14. Total number of fishers in both zones (Gulf Saint Vincent and Investigator Strait) reaches 22.
1982	Number of Investigator Strait zone permits reduced from eight to two. Total number of fishers in both zones (Gulf Saint Vincent and Investigator Strait) reaches 16.
1982	Triple rig trawl nets introduced.
1986	A review of management was completed by Prof Parzival Copes.
1986	A licence rationalisation strategy was implemented as an outcome of the review.
1987	The <i>Fisheries (Gulf St Vincent Prawn Fishery Rationalisation) Act 1987</i> is introduced.
1987	Two Investigator Strait entitlements are removed. Four GSVPF licences are also removed over the next four years and the two zones (Investigator Strait and Gulf Saint Vincent) are once again amalgamated.
1990	Prof Parzival Copes requested to complete his second review of the fishery.
1990	A total of 10 licences issued in the GSVPF.
1991	Fishery closed in June.
1991	A Select Committee of the House of Assembly of South Australia reviewed the fishery's management options.
1994	The fishery re-opened in February.
1995	A review of the fishery was conducted by Dr Gary Morgan (Morgan 1995).
1998	The first management plan for the fishery was introduced (Zacharin 1997).
2000	<i>Fisheries (General) Regulations 2000</i> enabled "large" vessels to enter the fleet.
2007	The second management plan was implemented (Dixon and Sloan 2007).
2011	A review of the fishery was undertaken by (Knuckey <i>et al.</i> 2011).
2012	The fishery was closed in November by unanimous agreement of industry. The T90-mesh codend was introduced.
2013	Morgan and Cartwright (2013) completed a review of the fishery management framework.
2014	A review of the stock assessment methods, processes and outputs was undertaken (Dichmont 2014). The fishery reopened in November 2014. Individual transferable units were introduced. A revised framework for longer-term management of the Gulf St Vincent Prawn Fishery was developed.
2017	The third management plan for the South Australian Commercial Gulf St Vincent Prawn Fishery was approved by the Minister for Agriculture, Food and Fisheries (PIRSA 2017).
2018	Establishment of the Gulf St Vincent Prawn Fishery Management Advisory Committee
2020	50% of unfished nights allocated in the 2019/20 fishing season carried-over to 2020/21 as a COVID-19 assistance measure.
2021	An independent review was undertaken of the harvest strategy included in the 2017 management plan (PIRSA 2017)
2021	Under-catch and over-catch provisions (10%) formalised.
2022	The fourth management plan for the South Australian Commercial Gulf St Vincent Prawn Fishery was approved by the Minister for Primary Industries and Regional Development (PIRSA 2022).
2023	Commercial fishing period changed to 1 November to 31 October in following year (January and February remain closed)

Table 3. Current management arrangements for the Gulf St Vincent Prawn Fishery.

Management tool	Current restriction
Permitted species	Western King Prawn (<i>Penaeus (Melicertus) latisulcatus</i>), Balmain Bug (<i>Ibacus</i> spp.), Southern Calamari (<i>Sepioteuthis australis</i>), <i>Metapenaeopsis crassima</i> .
Limited entry	10 licences
Licence transferability	Permitted
Corporate ownership	Permitted
Spatial and temporal closures	No fishing <10m depth or in aquatic reserves or marine parks (sanctuary zones/benthic protection areas)
Method of capture	Demersal otter trawl
Trawl rig	Single, double or triple
Trawling times	Not during daylight hours
Maximum combined headline length	27.43 or 29.26 m (non-amalgamated gear), 43.89 m (amalgamated gear)
Minimum codend mesh size	58 mm
Maximum vessel length	24 m
Maximum vessel power	340 kW
Catch and effort data	Daily logbook and catch disposal logbook submitted after each trip
Landing locations	Landings permitted anywhere in the State
Landing times	Landings permitted at any time during the season

1.3. Western King Prawn biology, biosecurity and prawn health

Previous stock assessment and stock status reports detail information relating to the distribution, habitat preferences, movement, growth, reproductive biology, life history and stock structure of the Western King Prawn stock in GSV (e.g. Dixon *et al.* 2011; 2012; Beckmann *et al.* 2015; Beckmann and Hooper 2016; McLeay *et al.* 2017; McLeay and Hooper 2018; 2019; 2020; 2021; 2022).

The potential effects of coastal pollutants, parasites and disease on growth, survival, reproduction and the overall health of Western King Prawn populations in South Australia are poorly understood. Roberts *et al.* (2010) assessed the disease status of prawns (focusing on viruses) collected from key nursery sites in both Spencer Gulf and Gulf St Vincent. A naturally occurring (endemic), and likely harmless, monodon-type baculovirus (MBV) was observed in ~60% of prawns. The MBV is a common virus known to occur throughout Australia.

White spot disease (WSD) is a highly contagious and lethal viral disease that was first detected in farmed prawns in south-east Queensland in December 2016. The most recent detections of WSD are from black tiger prawns (*Penaeus monodon*) at three prawn farms on the north coast of New South Wales between February and April 2023 ([National Pest and Disease Outbreaks 2023](#)). The virus can cause high rates of mortality in affected prawns and is the subject of a national surveillance program ([National Pest and Disease Outbreaks 2023](#)). To date, all samples that have been collected and tested within jurisdictions outside of Queensland and New South Wales have returned negative results.

1.4. Research program

There have been numerous fisheries' research projects relevant to the Western King Prawn stock in GSV. Research has been undertaken to investigate population dynamics and biology (King 1977; Kangas 1999; Xiao and McShane 2000; Tanner and Deakin 2001; Roberts *et al.* 2012), stock structure (Carrick 2003), biosecurity and disease (Roberts *et al.* 2009), fishing gear technology (McShane 1996; Broadhurst *et al.* 1999; Dixon *et al.* 2013; Gorman and Dixon 2015; McLeay 2021), trawling impacts (Tanner 2003) and to develop fisheries models (Xiao 2004; Noell *et al.* 2015). Previous stock assessment and stock status reports detail the biological information and the history of commercial catch used to assess the status of the Western King Prawn stock in GSV (Kangas and Jackson 1997; Xiao and McShane 1998; Boxshall *et al.* 1999; Boxshall and Williams 2000; Boxshall and Johnson 2001; Svane 2003; Svane and Johnson 2003; Svane and Roberts 2005; Roberts *et al.* 2007a, 2007b; 2008; 2009; Hooper *et al.* 2009; Dixon *et al.* 2011; 2012; Beckmann *et al.* 2015; 2016; McLeay *et al.* 2017; McLeay and Hooper 2018; 2019; 2020; 2021; 2022).

From 2011 to 2014, three separate independent reviews of the stock assessment and harvest strategy for the GSVPF were conducted (Knuckey *et al.* 2011; Morgan and Cartwright 2013; Dichmont 2014). As a result of these reviews, there was a rationalisation of the research program. The principal change was a reduction from four fishery-independent surveys (FISs) per year to one (conducted in May). A review of the harvest strategy and 2017 management plan between 2020 and 2021 recommended that two surveys per year were undertaken. The 2022/23 report focuses on two annual FISs, conducted in March and April/May 2023, noting that November/December surveys are also undertaken to inform fishing strategies pre-Christmas but are not used for the purposes of stock assessment. Fishery-independent information from surveys in March and April/May is then combined with fishery-dependent information collected from the

GSVVPF during the 2022/23 fishing season to assess the status of the Western King Prawn stock in GSV.

1.5. Information sources used for assessment

Fishery-independent data have been collected for the GSVVPF using surveys coordinated by SARDI since 1984. SARDI also maintains a comprehensive fishery-dependent catch and effort database for the GSVVPF using data obtained from South Australian Fishing Industry Council (SAFIC) annual reports between 1968 and 1987. Data from July 1987 were obtained from daily commercial logbooks provided to SARDI by GSVVPF licence holders.

1.6. Stock status classification

A national stock status classification framework was developed to enable the consistent assessment of the status of Australian fish stocks (Flood *et al.* 2012; 2014; Stewardson *et al.* 2016; 2018; Piddocke *et al.* 2021). The stock status classification framework of Piddocke *et al.* (2021), which the management plan for the GSVVPF refers to (PIRSA 2022), considers “*whether the current abundance (number or biomass [weight]) is at an adequate level and whether the level of fishing pressureis adequately controlled through management.* (www.fish.gov.au).” The system combines information on both the current stock size and level of catch into a single classification for each stock against defined biological reference points. The stock is then classified as ‘sustainable’, ‘depleting’, ‘depleted’, ‘recovering’, ‘negligible’, or ‘undefined’ (Table 4).

Table 4. Stock status terminology (Piddocke *et al.* 2021; www.fish.gov.au).

	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.

PIRSA has adopted the national stock status classification framework for South Australian fish stocks (Flood *et al.* 2012, 2014; Piddocke *et al.* 2021). Status is categorised for the Western King Prawn stock in GSV from a combination of two primary performance indicators as defined in the harvest strategy for the fishery (PIRSA 2022):

- 1) standardised fishery-independent survey (FIS) CPUE (kg/trawl-shot), which is the average of standardised CPUE from surveys conducted in March and April/May; and
- 2) standardised annual commercial catch per unit effort (CPUE) (kg/vessel-night).

To categorise stock status, estimates for each performance indicator are assessed in relation to how they align against their relative limit, trigger and target reference points as defined in the harvest strategy for the fishery (Tables 5 and 6) (Tables 9 and 10, respectively in PIRSA 2022).

Table 5. Reference points for performance indicators in the Gulf St Vincent Prawn Fishery (PIRSA 2022). Note, the LRP is set at a level estimated to be at Maximum Sustainable Yield (MSY) set (conservatively) at 40% unfished levels (PIRSA 2022).

Reference Point	B ₀	Standardised Commercial CPUE (kg/vessel-night)	Standardised FIS CPUE (kg/rawl-shot)
Limit (LRP)	0.4B ₀	492 kg/vessel-night	14.8 kg/rawl-shot
Trigger (TrRP)	0.5B ₀	615 kg/vessel-night	18.5 kg/rawl-shot
Target (TargRP)	0.6B ₀	738 kg/vessel-night	22.2 kg/rawl-shot

Table 6. Decision rules for classifying the status of Western King Prawn stock in GSV (PIRSA 2022). **When primary performance indicators are below the LRP, stock status will be interpreted in consideration of the trajectory of the performance indicators for the fishery. # If a majority of the performance indicators are declining the fishery will be classified as depleted, or where a majority of performance indicators are increasing the fishery will be classified as recovering. When primary performance indicators are at or above the LRP and below the TrRP, stock status will be interpreted in consideration of the trajectory of the performance indicators for the fishery. If a majority of the performance indicators are declining the fishery will be classified as depleting, or where a majority of performance indicators are stable or increasing the fishery will be classified as sustainable.*

		Standardised FIS CPUE (kg/trawl-shot)					
		<14.8	≥14.8	<18.5	≥18.5	<22.2	≥22.2
Standardised Commercial CPUE (kg/vessel-night)	<492	Depleted or Recovering *	Sustainable unless performance indicators are declining #		Sustainable		
	≥492						
	<615						
	≥615						
	<738						
	≥738						

2. METHODS

2.1. Fishery-independent surveys

Historically, surveys using commercial vessels with fishery-independent (SARDI) observers on-board, were conducted in GSV prior to the December, March, April and May harvest periods from 2004/05 to 2010/11, in April and May in 2011/12, and in May from 2013/14 to 2020/21. Surveys were typically undertaken using three to six vessels over two or three consecutive nights commencing on the second and third nights following the last quarter of the moon. There were two exceptions; 1) 2004/05 to 2007/08, when surveys were conducted during one night on the dark of the moon with approximately ten vessels; and 2) the 2013/14 survey, which was extended over the dark phase of the moon with only one vessel participating.

In 2021, a review of the harvest strategy and 2017 management plan recommended that, for stock assessment purposes, two surveys per year be undertaken to account for any within-season fluctuations in prawn abundance (PIRSA 2022). Beginning in 2021/22, March and April/May surveys were conducted within a timeframe of 2 days prior to/or 2 days after the new moon in March, and in April or May. Timing of April/May surveys is dependent on the timing of the monthly lunar phase. If the timing of the new moon in May is after 7 May, then the FIS is undertaken around the new moon period in April (PIRSA 2022). This flexibility in survey timing avoids any potential catch sampling bias associated with decreases in water temperature in the latter part of May. This report used historical data from March and April/May surveys conducted from 2004/05 to 2010/11, and in 2022/23, to examine trends in FIS CPUE since 2004/05.

T90-mesh codends with bycatch reduction grids were introduced into the GSVPF in 2012 to reduce discards. Consequently, vessels participating in surveys since 2011/12 have had a paired trawl configuration with one side of the trawl comprising a T90 mesh codend (57 mm) and the other side of the trawl comprising a diamond-mesh codend (51 mm). The reference levels relating to standardised FIS CPUE (kg/trawl-shot) described within the current harvest strategy are derived from historical data collected from diamond-mesh (51 mm) codends only since 2004/05 (PIRSA 2022). Consequently, only survey data collected from diamond-mesh codends are presented in this report as they are more informative from a historical perspective and directly inform stock status determination.

A total of 109 fixed survey sites are located in Gulf St Vincent (Figure 4). From 2004/05 to 2022/23, the number of sites sampled ranged from 92–109, except for 2013/14 where a reduced survey of 46 sites was completed. In 2023, 101 trawl shots were completed on the nights of 20 and 21 March 2023 and 105 shots were completed on the nights of

18 and 19 April 2023. Each shot began close to a known location (recorded by Global Positioning System, GPS), considering bottom trawl conditions (e.g. fouling), and continued in a set direction for a period of 30 minutes. The total distance covered was dependent on trawl speed, which was influenced by vessel power, tide and weather conditions. Data collected for each shot location included the total catch weight, catch weight of each prawn-size grade, number of nets used, trawl duration, tide direction, and the number of prawns in a 7 kg bucket ('bucket count' - recorded before grading of the catch has occurred and used as a rapid measure to estimate prawn size).

The number of prawns in a 7 kg subsample collected from diamond-mesh codends was used to estimate mean prawn size (N prawns/kg), with higher estimates representing smaller prawns and lower estimates representing larger prawns. The GPS locations of each trawl station were used to map prawn size and CPUE across the survey area.

In 2022, the GSVPF updated its commercial fishing strategy guidelines with respect to prawn size and catch rate criteria. Noting that these guidelines are an industry initiative to maximise yield per recruit and profit, and are not regulated by PIRSA, areas classified as fishable in the GSVPF are those characterised by:

- a size of ≤ 224 prawns/ 7kg bucket (equating to ≤ 32 prawns/kg).
- a catch rate that is:
 - ≥ 0.5 kg/min/net (equating to nominal FIS CPUE of ≥ 30 kg/trawl-shot and a commercial fishing '*trigger*' limit of 480kg/8 hours fishing).
 - ≥ 0.75 kg/min/net (equating to nominal FIS CPUE of ≥ 45 kg/trawl-shot and a commercial fishing '*target*' level of 720kg/8 hours fishing).

Survey information is used to guide subsequent fishing strategies. Consequently, this report describes the spatial distribution of prawn size and catch rates recorded at survey sites in relation to these criteria.

A random sample of 100 prawns was also taken from each shot to obtain information on sex ratio and length-frequency. Length-frequency measurements for prawns sampled from the diamond-mesh codend in April/May surveys were used to determine the FIS Recruitment Index (FRI), which is estimated as the catch rate of recruits per trawl-hour, with 'recruits' defined by prawn size: <33 mm CL for males and <35 mm CL for females.

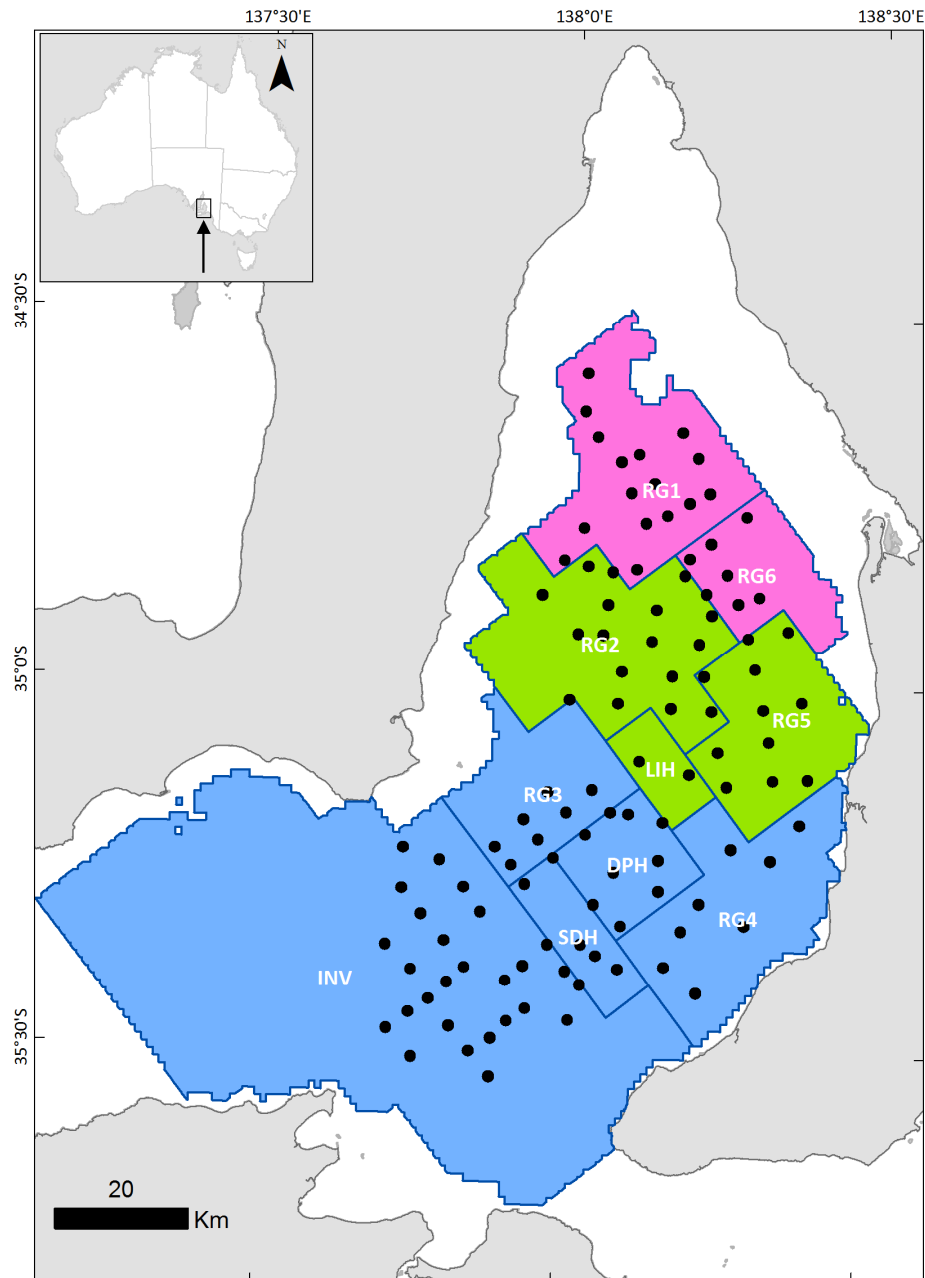


Figure 4. The 109 survey stations sampled by FISs and regions of the Gulf St Vincent Prawn Fishery. The northern gulf (pink) includes Region 1 (RG1) and Region 6 (RG6), the central gulf (green) includes Region 2 (RG2), Region 5 (RG5) and Little Hole (LIH), and the southern gulf (blue) includes Deep Hole (DPH), Southern Deep Hole (SDH), Region 3 (RG3), Region 4 (RG4) and Investigator Strait (INV).

2.2. Fishery statistics

2.2.1. Catch and effort

Fishery catch (t) and effort (vessel-nights or trawl-hours) data are presented for fishing seasons between 1968/69 and 2022/23. In this report, a 'fishing season' is defined as the period from 1 November to 31 July of the following year, with a closure in January and February. Fisher-estimated prawn catch for each shot was adjusted using validated post-harvest catches reported in monthly logbooks. Catch and effort data are reported separately from FIS catches, which are retained for sale by the SVGPBOA.

The main spawning period for Western King Prawns in GSV extends from November to March, so catch and effort data are also presented for early (November–December), late (January–March) and non-spawning (April–October) periods. The spatial distribution of the annual harvest per fishing block is presented from 2011/12–2022/23.

All data are entered and maintained by PIRSA Information Services. Data are checked for errors during data entry, and further validated via database lookup tables and validation routines that are activated during data entry and reporting operations. PIRSA staff contact licence holders to correct any errors or missing information identified in the quality assurance process.

2.2.2. Prawn size

Mandatory reporting of commercial prawn-grade data in daily logbooks was introduced in 2005/06. The grade is determined from the number of prawns to the pound (e.g. 'U10' = under 10 prawns per pound). To facilitate interpretation of the prawn-grade data, grades were assigned to four size categories (Table 7). Soft and broken prawns that were not graded, were assigned to a fifth category ('S&B'). Data presented are from commercial fishing nights only and reported as the proportion of the total catch occurring in each of the size classes (see Dixon *et al.* 2012).

Table 7. Categories assigned to reported prawn grades from commercial logbook data for the Gulf St Vincent Prawn Fishery. The grade is determined from the number of prawns to the pound (e.g. 'U10' = under 10 prawns per pound).

Prawn grade	Categories in logbook
Extra Large	U6 U8, XL U10, L
Large	9/12 U12 LM 10/15 13/15 10/20 (50%), 12/18 (50%)
Medium	10/20 (50%), 12/18 (50%) 16/20, M
Small	SM, 19/25 21/25 S, 20+, 21/30 26+ 30+, 31/40
Soft & Broken	S/B, B&D, MIX, REJ, SMS, blank, ERR

2.3. Catch rate standardisation

CPUE is commonly used as an indicator of relative biomass (stock abundance) in crustacean fisheries worldwide. However, to improve the relationship between CPUE and relative biomass, it is important to standardise CPUE to account for the influence of variables that are not related to abundance. Generalised linear models (GLMs) within R statistical software (R Core Team 2023) were used to standardise FIS CPUE (kg/trawl-shot) since 2005 and annual commercial CPUE (kg/vessel-night) since 1989/90. Models incorporated a Gaussian error structure, with cubic-root transformation and identity link function.

Estimates of standardised annual commercial CPUE and standardised FIS CPUE will differ from previous reports due to the GLM updates implemented in the latest harvest strategy and management plan for the fishery (PIRSA 2022) and as new data from the latest season (e.g. 2022/23) are added to the GLM. In 2022/23, annual estimates of standardised FIS CPUE (kg/trawl-shot) were calculated from the average of predicted monthly CPUE estimates for March and April/May FISs. Variables used in the GLM for standardising FIS CPUE were fishing year-survey (combined term), region, vessel, depth and sea-surface temperature (SST), with effort used as an offset variable. Variables used for standardising annual commercial CPUE were fishing year, month, region, licence number, depth, lunar phase (luminosity), SST and effort. Luminosity data were obtained from the [NASA Horizons Web-interface](#). Standardised estimates of CPUE are presented with 95% confidence intervals.

3. RESULTS

3.1. Fishery-independent surveys

3.1.1. CPUE

March surveys were not conducted between 2011/12 and 2020/21 so FIS CPUE in this period was not estimated. In 2022/23, the estimate of nominal March FIS CPUE was 17.6 kg/trawl-shot, which is the second lowest estimate on record (Figure 5a). April/May FIS CPUE has been estimated since 2004/05. Nominal April/May FIS CPUE declined from 42.3 ± 3.5 kg/trawl-shot in 2007/08 to a historical low of 22.3 ± 2.1 kg/trawl-shot in 2011/12 prior to the fishery being closed in 2012/13 and 2013/14 (Figure 5a). The fishery was then reopened in 2014/15, following a reduced survey in 2013/14 that recorded an estimate of nominal April/May FIS CPUE of 56.5 ± 5.0 kg/trawl-shot. From then, nominal April/May FIS CPUE generally declined reaching 23.1 ± 2.1 kg/trawl-shot in 2020/21 before increasing 25% in 2021/22, to 28.9 ± 2.6 kg/trawl-shot (Figure 5a). In 2022/23, nominal April/May FIS CPUE declined to its lowest level on record of 21.8 ± 1.7 kg/trawl-shot.

Fishing year-survey, region, vessel and depth were all highly significant variables in the GLM used to standardise estimates of nominal FIS CPUE from March and April/May FISs (Table 8). The term 'fishing year-survey' explained ~9% of the deviance in the model. A total of 11% of model deviance was explained by the factors 'region' (6%), 'depth' (3%) and 'vessel' (2%) indicating that 80% of the deviance was caused by unknown factors. Sea surface temperature (SST) was not a significant term in the model (Table 8).

Standardised FIS CPUE remained above the target reference point (TargRP; 22.2 kg/trawl-shot) in 14 out of 18 years since 2014/15 (Range: 21.2–49.2 kg/trawl-shot) (Figure 5b). Since 2018/19, standardised FIS CPUE has declined and was below the TargRP between 2020/21 and 2022/23. The 2022/23 estimate of 21.3 [17.0–26.4, 95% CI] kg/trawl-shot is the second lowest estimate on record, 4% below the TargRP and 15.1% above the trigger reference point (TrRP; 18.5 kg/trawl-shot) (Figure 5b).

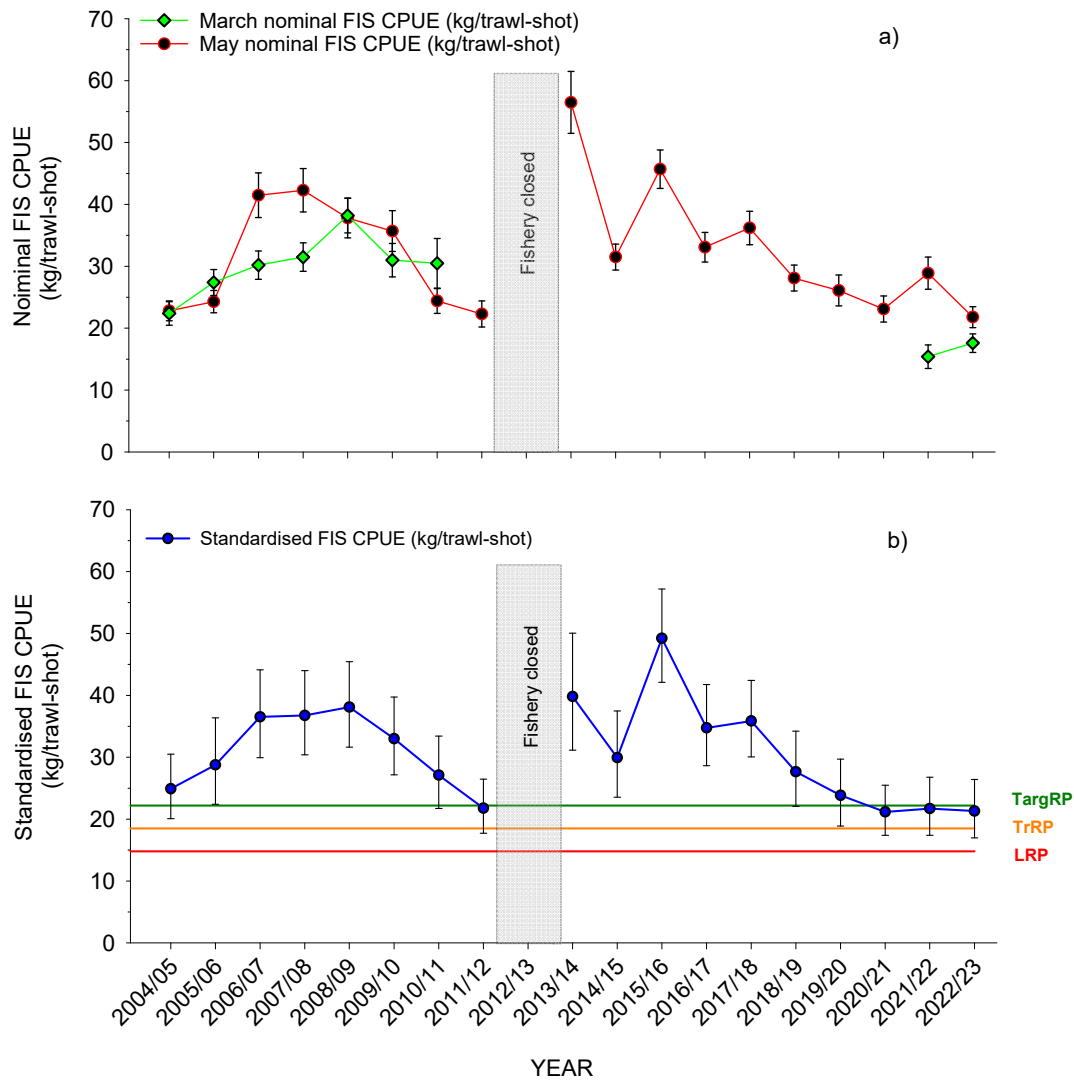


Figure 5. Catch Per Unit Effort estimates calculated from diamond-mesh codends during March and April/May surveys between 2004/05 and 2022/23 (a) nominal FIS CPUE (kg/haul-shot) from March (green line) and April/May (red line) surveys; (b) standardised FIS CPUE (kg/haul-shot), which is the average standardised FIS CPUE from March and April/May surveys. Note, a reduced survey was conducted in May 2013/14 (N=46 trawl shots). Error bars = standard error for estimates of nominal CPUE, and upper and lower (95%) confidence intervals for standardised CPUE. Grey area indicates the period when no survey occurred during the fishery closure.

Table 8. Analysis of deviance (Type II test) for the GLM used to standardise survey CPUE for the Gulf St Vincent Prawn Fishery. Abbreviations: SS, sum of squares; df, degrees of freedom; *F*, *F*-statistic.

Effect	SS	df	<i>F</i>
Fishing year-survey	335	41	11.0***
Region	249	7	47.6***
Vessel	64	13	6.6***
Depth	102	1	137.1***
SST	0.02	1	0.03 NS
Residuals	3,110	4,166	NA
Significance: *** $p < 0.001$, NS = non-significant			

3.1.2. Prawn Size

Mean prawn size (N prawns/kg (PP/KG)) is estimated from the 7-kg subsample taken per shot and has a negative relationship with the number of prawns per kg (i.e. smaller mean prawn size = more prawns per kg). In March FISs from 2004/05 to 2010/11, the number of prawns per kg measured from diamond mesh increased steadily from 27.5 ± 0.6 to 35.4 ± 0.8 prawns/kg (Figure 6). In the 2022/23 March FIS, the number of prawns per kg was 36.8 ± 0.9 , equating to the smallest mean prawn size estimated from March FIS (Figure 6).

Trends in mean prawn size estimated from April/May FISs from 2004/05 to 2011/12 are similar to those estimated from March FISs. During this period the number of prawns per kg increased steadily from 31.0 ± 1.0 to 37.1 ± 1.2 prawns/kg (Figure 6). Following the fishery closure, the number of prawns per kg decreased 11.1% to 33.0 ± 1.1 in 2013/14, and in 2014/15, an estimate of 29.3 ± 0.8 prawns per kg was recorded, equating to the largest mean prawn size estimated from April/May FIS (Figure 6). Mean prawn size then decreased from 2014/15 and by 2018/19 was the smallest on record (43.2 ± 1.7 prawns/kg). Prawn size then increased in 2019/20 (38.7 ± 0.9 prawns/kg) and further in 2020/21 (36.3 ± 1.2 prawns/kg) (Figure 6). In 2022/23, the number of prawns per kg from the April/May FIS was 38.5 ± 1.4 , the fourth lowest estimate of mean prawn size recorded from April/May FISs.

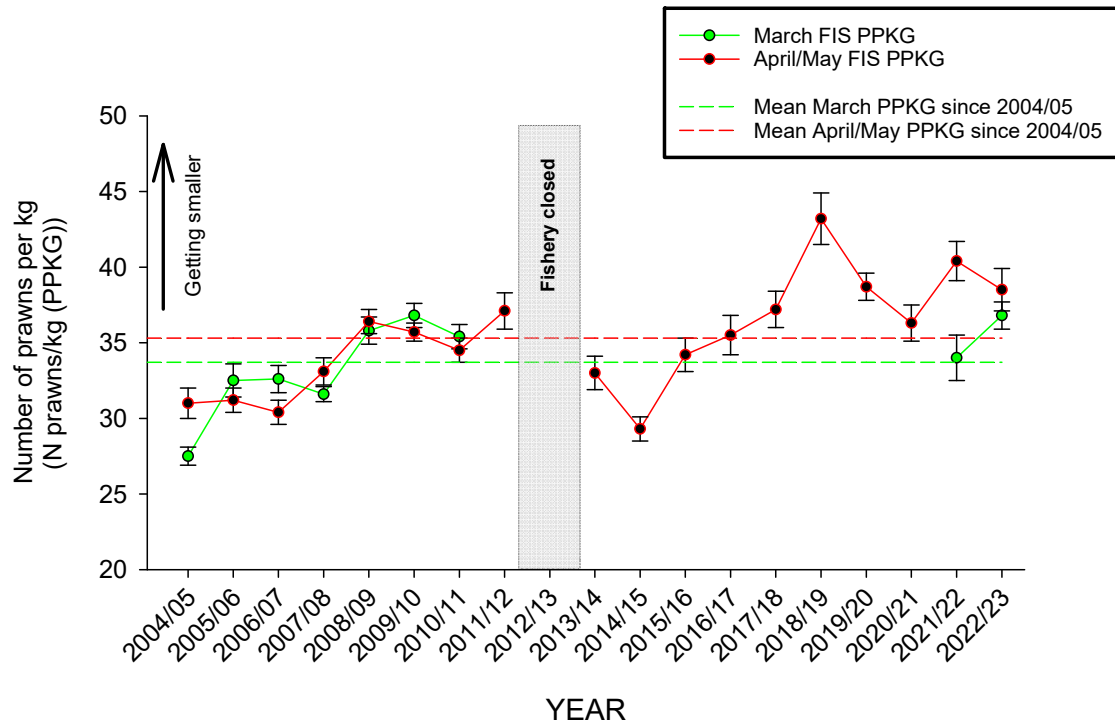


Figure 6. Prawn size as estimated by the mean number of prawns/kg calculated from diamond-mesh codends during March (green) and April/May surveys (red) between 2004/05 and 2022/23. Note, no March surveys were undertaken from 2011/12–2020/21.

3.1.3. Spatial patterns in CPUE and size

Figure 7 depicts temporal trends in the percentage of March and April/May survey sites characterised by prawn aggregations averaging ≤ 32 prawns/kg and catch rates of ≥ 30 kg/haul-shot ('fishable' sites). No March surveys were undertaken between 2011/12 and 2020/21. Spatial patterns in prawn size and abundance in March and April/May are generally indicative of smaller prawns entering the fishery from recruitment areas in northern Gulf St Vincent (Figures 8 and 9).

Historically, the percentage of March survey sites averaging ≤ 32 prawns/kg and catch rates of ≥ 30 kg/haul-shot ranged between 7.5% (2009/10) and 28.8% (2006/07) (Figures 7 and 8). In the March FIS in 2022/23, 1% of sites ($N = 1$ site) had prawn aggregations with this size and catch rate criteria (Figures 7 and 8).

The percentage of April/May survey sites having prawn aggregations averaging ≤ 32 prawns/kg and catch rates of ≥ 30 kg/haul-shot ranged from 7.6% in 2011/12 prior to the fishery closure, to 41.3% in 2013/14 prior to the fishery reopening (Figure 7). The percentage of sites characterised by these size and catch rate criteria has decreased since 2018/19 (Figure 7) with the April/May FIS in 2022/23 recording the lowest percentage of 'fishable' sites of any April/May FIS (Figures 7 and 9). In the April/May FIS

in 2022/23, a total of 6.7% of sites (N = 7 sites) had prawn aggregations averaging ≤ 32 prawns/kg and catch rates of ≥ 30 kg/rawl-shot (Figures 7 and 9).

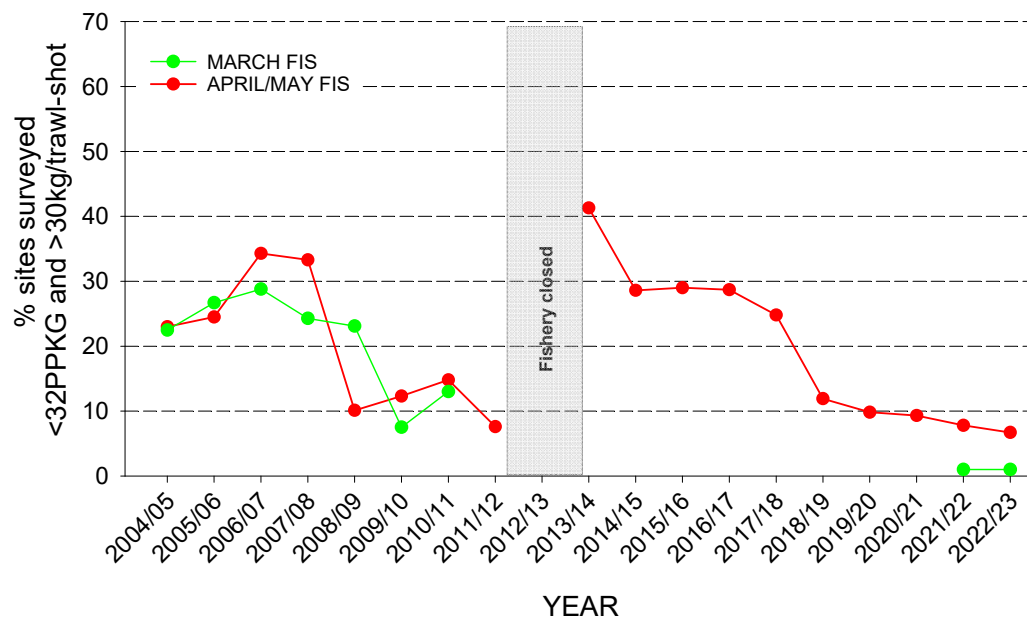


Figure 7. Trends in the percentage of March (green) and April/May survey (red) sites with prawn aggregations of criteria <32 prawns/kg and CPUE of >30 kg/rawl-shot between 2004/05 and 2022/23.

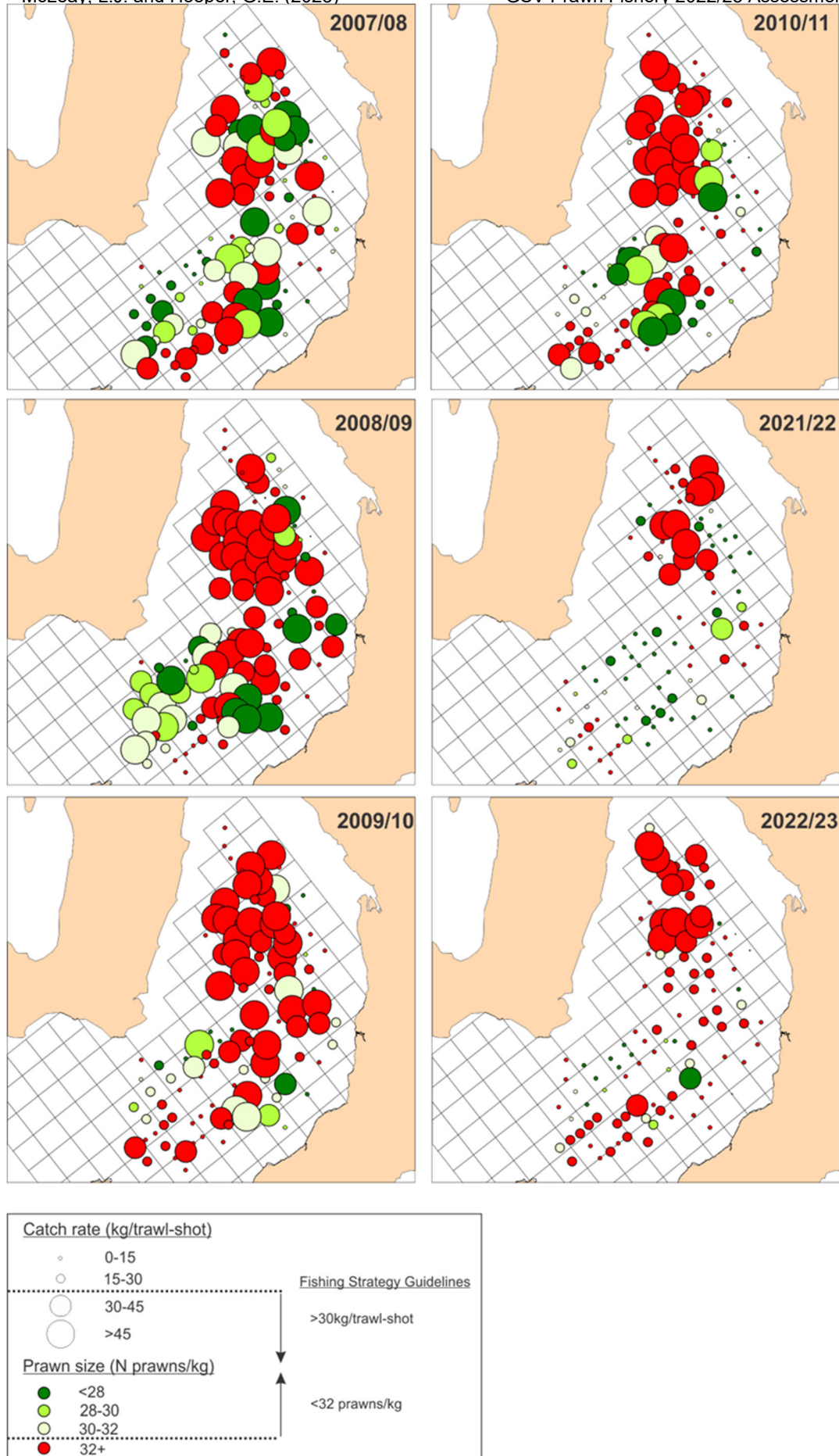


Figure 8. Catch rate and mean size of prawns sampled from the diamond-mesh codend during March FISs in the GSVPF from 2007/08–2010/11 and 2021/22–2022/23. Note, no March surveys were undertaken from 2011/12–2020/21. Data from 2004/05–2006/07 not presented.

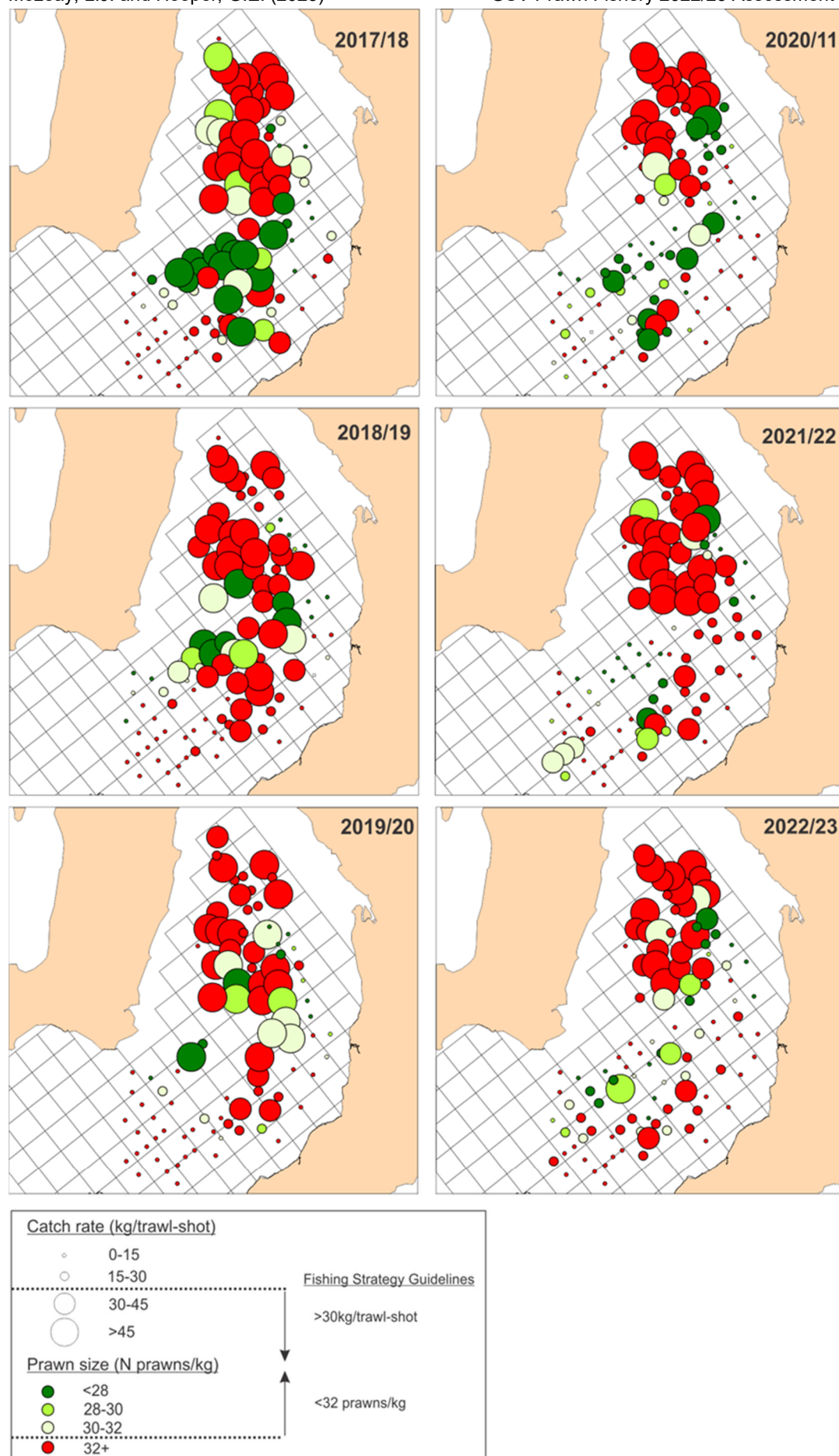


Figure 9. Catch rate and mean size of prawns sampled from the diamond-mesh codend during April/May FISs in the GSVPF from 2017/18–2022/23.

3.1.4. Recruitment

FRI estimates show high interannual variability, ranging between 239 and 1,186 recruits.h⁻¹ since 2004/05 (Figure 10). Since the fishery closure between 2012/13 and 2013/14, the FRI averaged 751 ± 86 recruits.h⁻¹. In 2022/23, the FRI was estimated from a total of 102 completed trawl shots and was 383 ± 46 recruits.h⁻¹ (Figure 10). This estimate is approximately half the average FRI recorded since 2013/14.

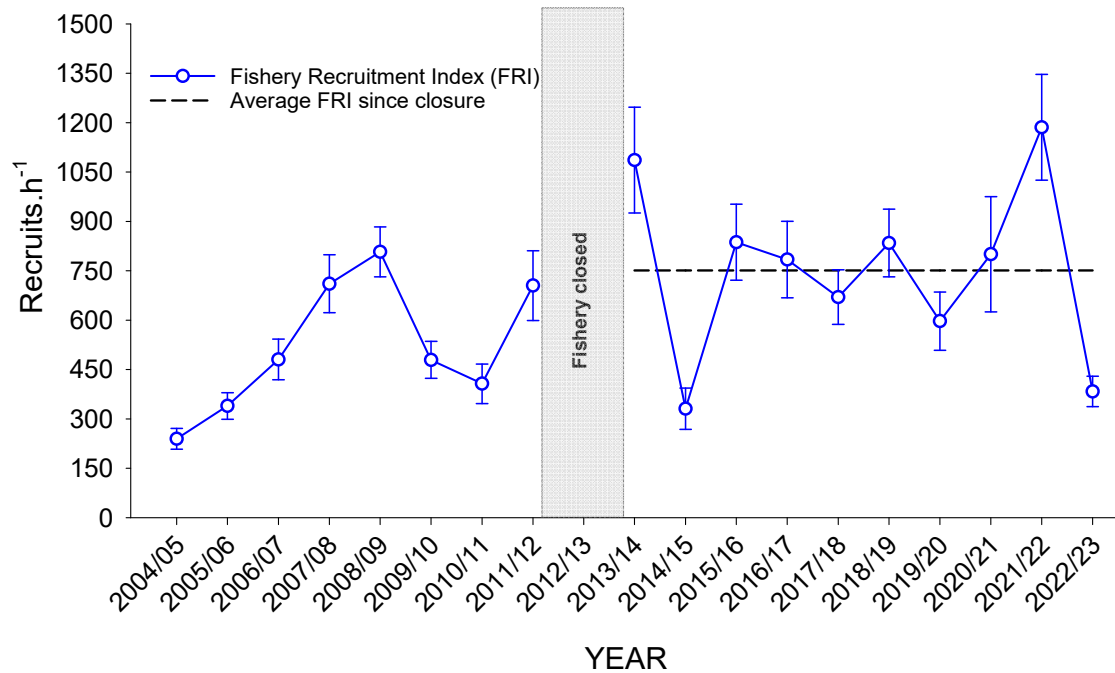


Figure 10. The FIS recruitment index (FRI) (recruits.h⁻¹) calculated from diamond-mesh codends during April/May surveys between 2004/05 and 2022/23.

3.2. Fishery statistics

3.2.1. *Catch and effort*

The total commercial catch of Western King Prawn in the GSVPF in 2022/23 was 152.0 t, with an additional 4.8 t taken in the November 2022, March and April/May 2023 surveys (Figure 11a, Appendix 1). The 2022/23 catch is an increase of 9.7% since 2021/22 but is the fifth lowest on record, and 28% below, the mean annual catch recorded since 2000/01 (Figure 11a).

In 2022/23, 50.6 t of the catch was taken during the early spawning period prior to Christmas (November–December), which was 33% of the total annual catch. Catch taken during the late spawning period (January–March) in 2022/23 (24.0 t) comprised 16% of the total catch and was 28% more than in the same period in 2021/22 (18.8t) (Appendix 1). The highest percentage of the 2022/23 catch (77.4 t, 51%) was harvested during the non-spawning period (April–July).

In 2022/23, commercial fishing was conducted over 319 vessel-nights. This effort comprised 81% of the 392 vessel-night TACE, which included 390 vessel-nights for the 2022/23 season and an additional 2 vessel-nights carried over from the 2021/22 season (Figure 11b). A total of 83 vessel-nights was fished pre-Christmas in 2022/23. A total of 3,020 trawl-hours was recorded in 2022/23, which is 8% greater than the average trawl-hours reported since the fishery reopened in 2014/15 ($2,788 \pm 112$ trawl-hours; Figure 11c).

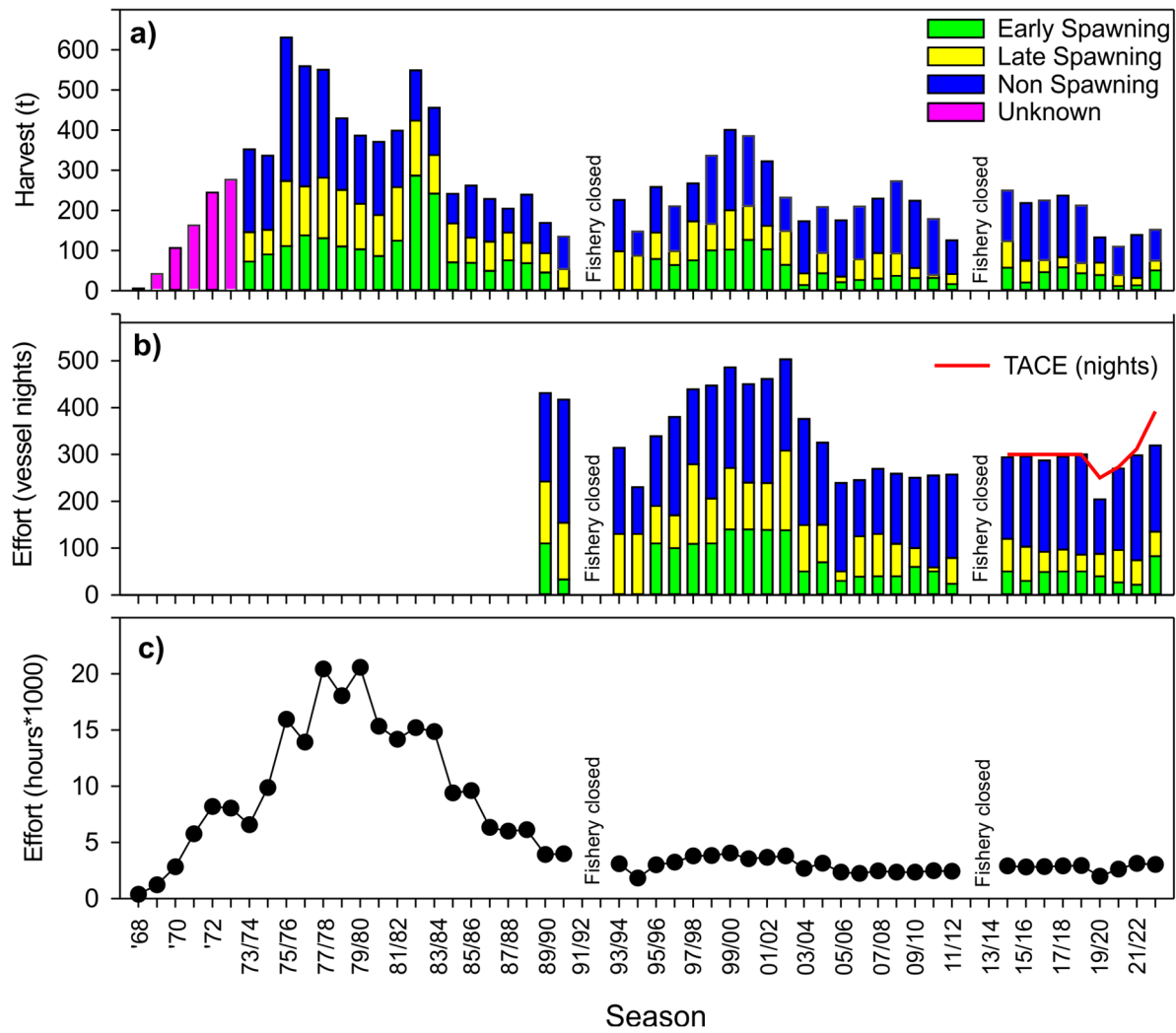


Figure 11. Fishery-dependent catch and effort data for the Gulf St Vincent Prawn Fishery since 1968; (a) annual catch (t) and (b) effort (vessel-nights) separated by early spawning (November–December), late spawning (January–March) and non-spawning (April–October) periods; and (c) annual commercial effort (hours * 1000). Catch data from surveys not included.

3.2.2. CPUE

Fishing year:month, region, lunar phase, lunar phase (lagged), licence number, sea surface temperature and effort were significant variables in the final model (Table 9). Effort was the most influential variable, explaining 77.3% of the total model deviance. Other significant variables explained a total of 8.0% of the total model deviance and 14.7% of the deviance was caused by unknown factors. Depth was not a significant term in the model (Table 9).

Table 9. Analysis of deviance (Type II test) for the GLM used to standardise annual commercial catch in the Gulf St Vincent Prawn Fishery. Abbreviations: SS, sum of squares; df, degrees of freedom; *F*, *F*-statistic.

Effect	SS	df	<i>F</i>
fishing year:month	11,118	169	65.4***
region	212	7	30.0***
lunar phase	182	1	180.5***
lunar phase (lagged)	61	1	60.8***
licence no	153	9	16.9***
sst	63	1	62.7***
effort	114,618	1	113864.8***
depth	0.11	1	0.11 (NS)
residuals	21,800	21,657	

significance: *** $p < 0.001$. NS = non-significant

Estimates of standardised annual commercial CPUE since 1989/90 are higher than estimates of nominal CPUE (Figure 12). This can be attributed to effort being fixed in the GLM at a typical vessel-night value of ~9 hours, and post 2012, the model accounting for reductions in catch following introduction of T90-mesh into the fishery. Despite the differences in scale of annual nominal and standardised CPUE estimates, the trend in both CPUE metrics is similar over time.

From 1993/94 to 2004/05, estimates of standardised annual commercial CPUE ranged from 713 [667–761, 95% CI] kg/vessel-night in 2004/05 to 935 [891–981, 95% CI] kg/vessel-night in 2000/01 (Figure 12). From 2004/05, standardised annual commercial CPUE steadily increased, reaching 1,056 [992–1121, 95% CI] kg/vessel-night in 2008/09 before declining to 735 [680–794, 95% CI] kg/vessel-night in 2010/11. The fishery was then closed in 2012/13 and 2013/14.

Following reopening of the fishery in 2014/15, the estimate of standardised annual commercial CPUE was the highest estimate on record at 1200 [1132–1272, 95% CI]

kg/vessel-night and 63% above the target reference point (TargRP). Standardised annual commercial CPUE then declined but remained between 43–56% above the TargRP of 738kg/vessel-night between 2015/16 and 2019/20 (Figure 12). Standardised annual commercial CPUE then declined 28% further from 2019/20 to 2020/21, and in the last three seasons has remained <15% above the TargRP. In 2022/23, standardised annual commercial CPUE was 832 [781–886, 95% CI] kg/vessel-night, which is a 4% increase since 2021/22 (799 [751–849, 95% CI] kg/vessel-night) and 12.7% above the TargRP (Figure 12).

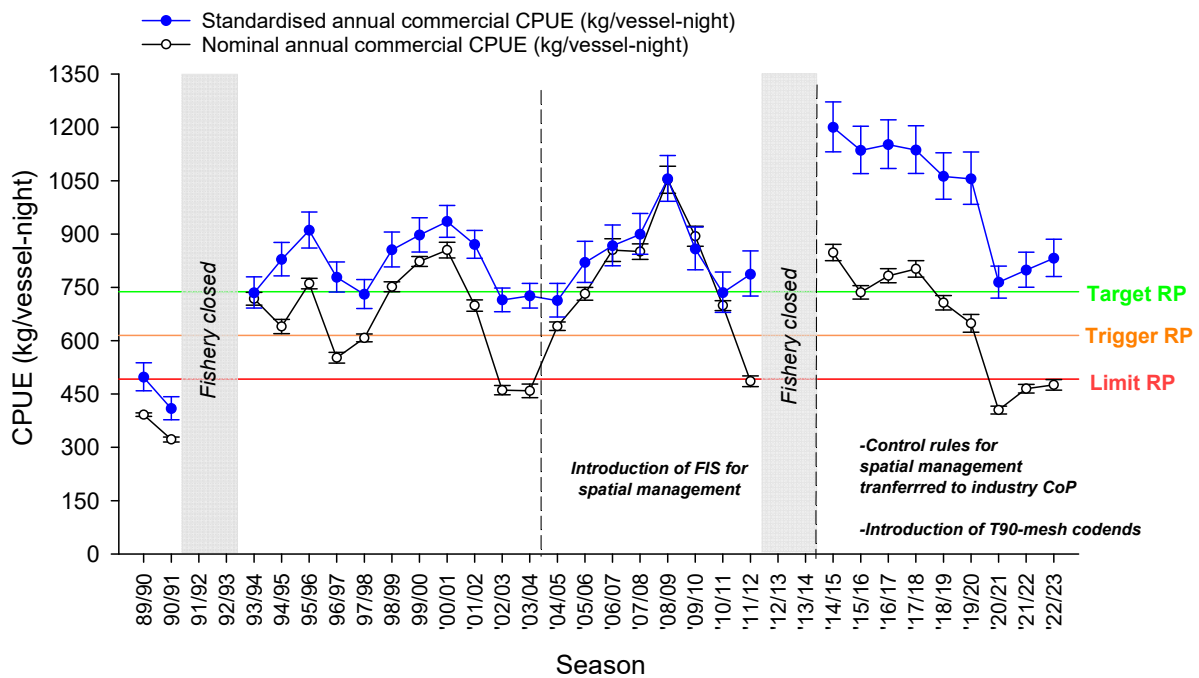


Figure 12. Comparison of standardised annual commercial CPUE and nominal annual commercial CPUE (kg/vessel-night) in the Gulf St Vincent Prawn Fishery from 1989/90–2022/2023. Error bars are \pm standard error for nominal CPUE, and upper and lower (95%) confidence intervals for standardised CPUE.

3.2.3. Spatial patterns in catch and effort

From 2004/05 to 2011/12, FISs were used to spatially control the areas harvested in GSV leading to a decline in the number of blocks that were fished (Figure 13). From 2014/15, the number of surveys was reduced, control rules for spatial management were transferred and adopted into the SVGPBOA Industry Code of Practice (see Section 1.2.2), and the number of blocks that were fished subsequently increased. In 2022/23, fishing took place in 25 blocks in November–December and 61 blocks in the remaining months of the fishing season (Figures 13 and 14).

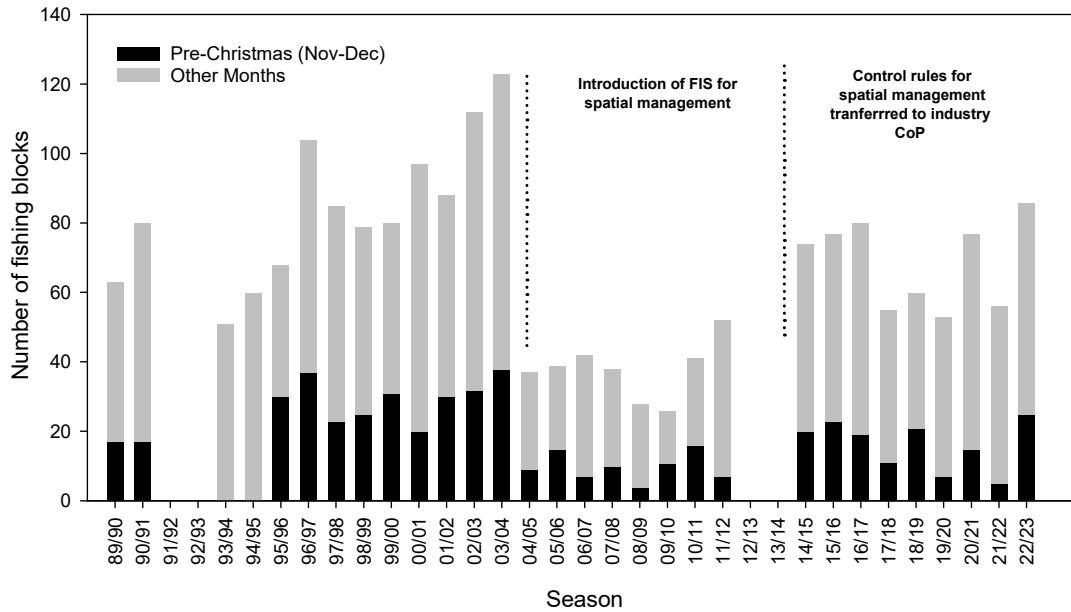


Figure 13. The number of blocks fished pre-Christmas (November and December) and all other months in the Gulf St Vincent Prawn Fishery from 1989/90–2022/23.

Since the fishery reopened in 2014/15, a relatively high proportion of the catch has been taken in blocks located in the central and southern regions of GSV (season range: 63–91%) (Figure 14). In 2022/23, central regions (RG2, RG5, LIH) of GSV contributed to 49% of the catch and southern regions (RG3, RG4, DPH SDH INV) contributed to 13% of the catch. Similar to 2020/21 and 2021/22, the highest catch in 2022/23 was recorded from RG2. Catch reported from this region comprised 39% (58.7 t) of the total annual catch (Figure 14). A total of 49.8 t was also recorded from RG1 in 2022/23, comprising 33% of the total catch.

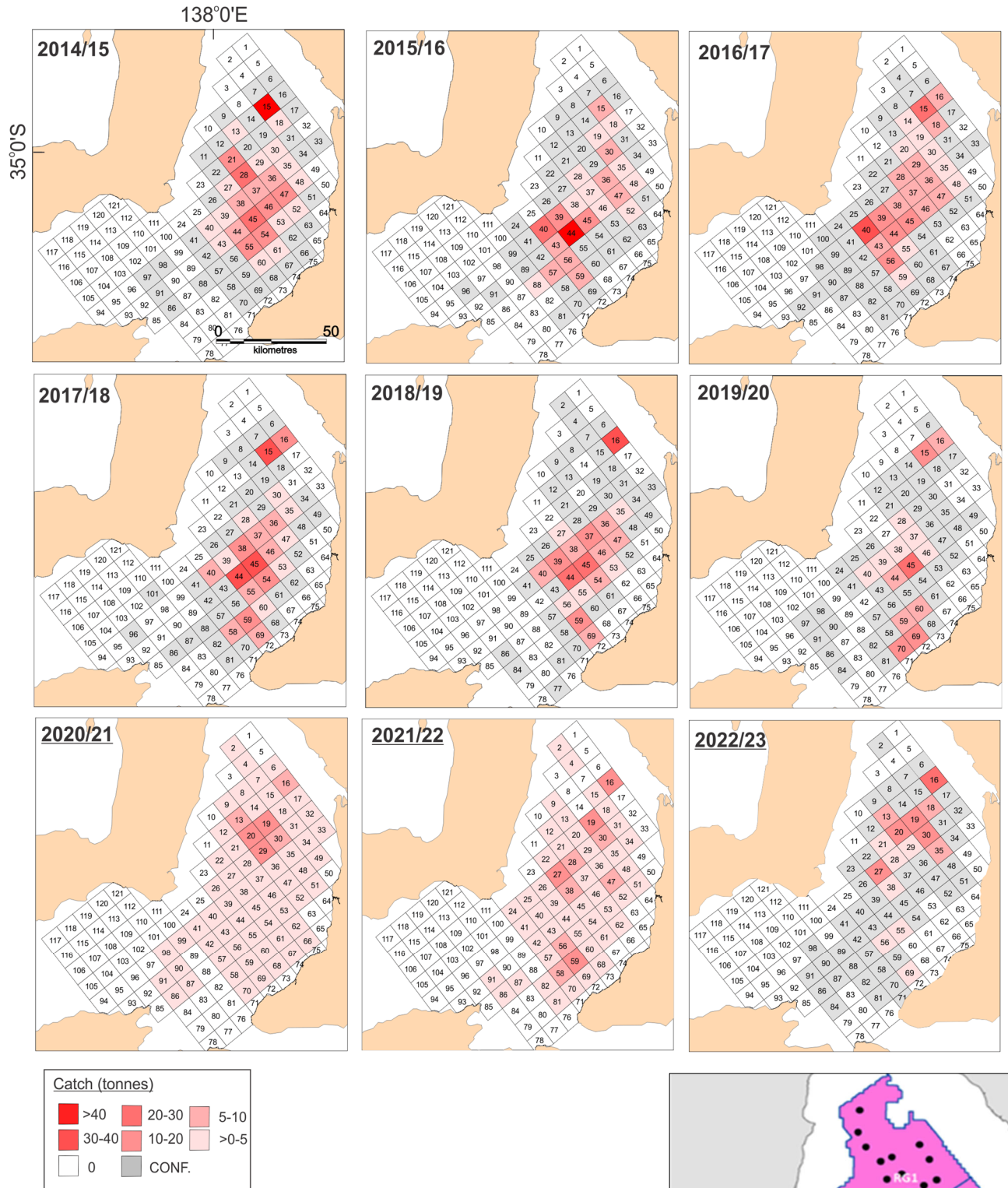
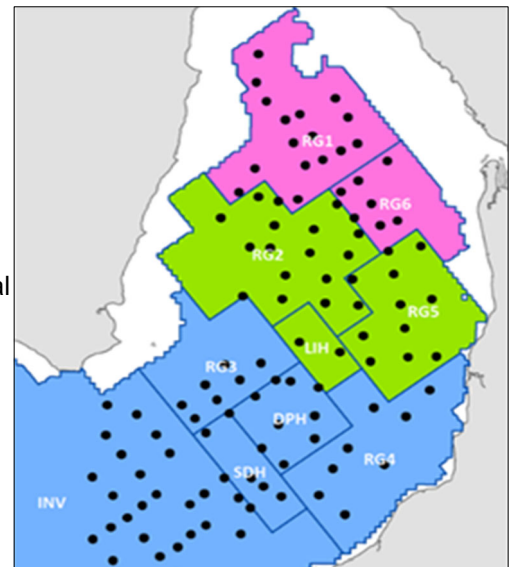


Figure 14. The annual catch per fishing block in the Gulf St Vincent Prawn Fishery from 2014/15–2022/23. Confidential data from <5 licence holders are depicted in grey and typically <5 t. Confidential publication in the 2020/21–2021/22 seasons. Map on bottom right shows regions used to describe the spatial distribution of fishing (see Figure 4 for more detail).



3.2.4. Prawn size

Since 2005/06, when grade information was first collected through daily logbooks, the annual catch of Western King Prawn in the GSVPF has comprised, on average, 24% extra-large prawns, 38% large prawns, 23% medium prawns and 8% small prawns (Figure 15). Soft and broken prawns have historically comprised a relatively low percentage of the catch (average since 2005/06: $7.0 \pm 0.3\%$).

From 2005/06 to 2010/11, the percentage of large and extra-large prawns in the catch decreased, and a corresponding increase in the proportion of small and medium prawns was recorded (Figure 15a, b, c). Following the re-opening of the fishery in 2014/15, extra-large (U6–U10 prawns per pound) and large (10/15 prawns per pound) prawns comprised 69% of the total catch (Figure 15a, b). The percentage of extra-large and large prawns in the catch then remained similar between 2014/15 and 2017/18 (66–69%). From 2018/19, the percentage of extra-large and large prawns in the catch decreased, comprising on average $55.0 \pm 1.1\%$ of the total catch (Figure 15b, Appendix 2). In 2022/23, extra-large and large prawns comprised 53% of the total catch and small and medium prawns comprised 40% of the total catch (Figure 15c, Appendix 2). In 2022/23, soft and broken prawns comprised 7% of the total catch (Figure 15a, Appendix 2).

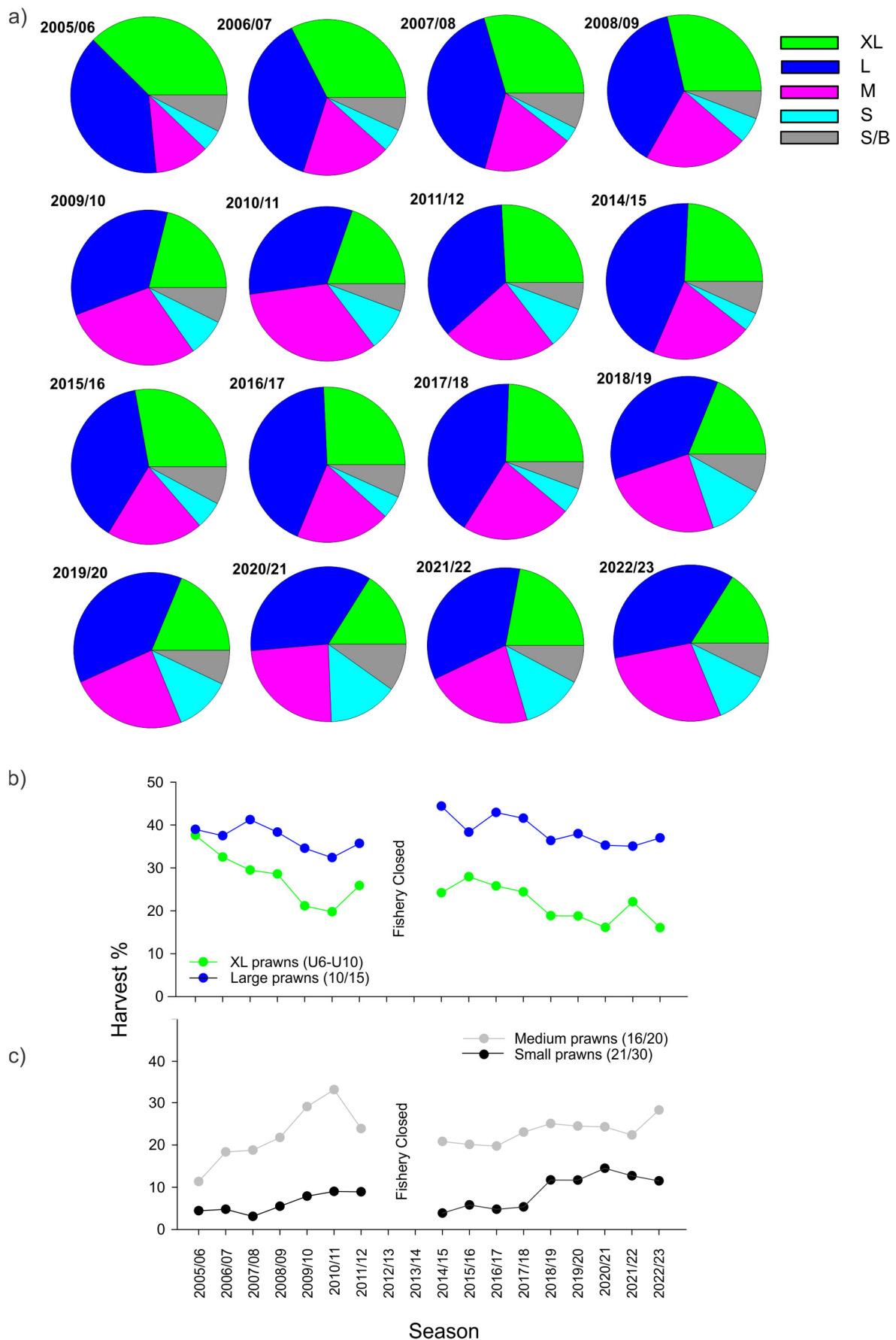


Figure 15. a) Size-grade composition (%) of annual harvests in the Gulf St Vincent Prawn Fishery from 2005/06–2022/23; b) Temporal trends in harvest composition of extra-large (XL) and large prawns; c) Temporal trends in harvest composition of medium and small prawns (see Table 7 for prawn grade composition categories).

4. DISCUSSION

4.1. Information sources and data uncertainty

Information available for the assessment of the GSV Western King Prawn stock include data from fishery-independent surveys from 2004/05 to 2021/22, and fishery catch and effort data since 1968, and are both considered high standard (Dichmont 2014). The recently adopted management plan for the fishery provides the decision rules for classifying the status of the Western King Prawn stock in GSV (PIRSA 2022). It uses limit, trigger and target reference points defined for two performance indicators relating to stock abundance (PIRSA 2022). The performance indicators are estimated from fishery-independent and fishery-dependent data.

4.1.1. Fishery-independent data

A fishery-independent survey program has been undertaken since December 2004 and is a key component in the assessment of status of the Western King Prawn stock in GSV. The methods used to collect the data have remained relatively consistent, despite adaptations to the survey program in recent years (see Section 2.1). Locations sampled in FISs have remained constant over time, and standardised FIS CPUE is considered the best available fishery-independent index of relative biomass. Under the harvest strategy within the newly adopted management plan, two surveys per year are undertaken to account for potential within-season fluctuations in prawn abundance (PIRSA 2022).

The introduction of T90-mesh codends fitted with Nordmøre-grids into the GSVPF in 2012 was based on the results of FRDC Project 2009/069 (Dixon *et al.* 2013), which indicated that this trawl-gear modification improved catch selectivity, reduced levels of bycatch and facilitated the escape of small prawns during fishing operations. As per the current management plan, data collected from diamond-mesh codends in the March and April/May FISs are used to estimate standardised FIS CPUE, prawn size and the FRI. Data collected from T90-mesh codends during the FISs enable calibration with data collected from diamond-mesh codends, thereby allowing mesh-type effects on FIS CPUE and commercial CPUE to be accounted for.

4.1.2. Fishery-dependent data

The trends in standardised annual commercial CPUE estimated from data recorded in daily commercial logbooks resemble the trends in standardised FIS CPUE since 2004/05. However, there is some uncertainty associated with the time series of data collected from the fishery used to estimate commercial CPUE. The spatial distribution of fishing effort has changed over time due to changes in spatial management of the fishery. The introduction

of four FISs per season between 2004/05 and 2010/11 likely increased catch efficiency during this time but the effects of surveys on catchability and resulting CPUE estimates remain difficult to quantify due to the potentially confounding effect of changes in stock biomass during this period. Also, estimates of standardised annual commercial CPUE are based on daily logbook data from 1989/90 because catch data available prior to this time are either not available or considered unreliable. Consequently, estimates of standardised CPUE from 1989/90 do not consider a period in the early development of the fishery when catches were considerably higher (1975/76–1983/84).

There is also some uncertainty associated with the calculation of prawn size from grade data that arises from: 1) data not being available from the entire fleet for all seasons; 2) differences in the grading among the vessels; and 3) uncertainty associated with the unvalidated grade data provided in logbooks (Dixon *et al.* 2012).

4.2. Status

Since its inception in 1967, the GSVPF has gone through several cycles characterised by periods of increasing catch and CPUE, followed by subsequent declines in recruitment, catch, CPUE and fishery performance, and resulting closure periods (1991/92–1992/93 and 2012/13–2013/14) (Morgan and Cartwright 2013). In 2021, a bio-economic model developed for the GSVPF was updated with biological, catch and economic information, and used to inform the development of a new harvest strategy (Noell *et al.* 2015; PIRSA 2022). Model outputs indicated that the relative biomass of the Western King Prawn stock had fluctuated at or above 60% of unfished biomass levels since the mid-1990s. The bioeconomic model was then used to predict levels of effort (TACE) that would on average hold the stock at a target level of 60% unfished biomass and a limit level of 40% unfished biomass (MSY). Under the harvest strategy, the status of the Western King Prawn stock in GSV is prescribed relative to the reference points for standardised commercial and FIS CPUE associated with these levels of biomass (PIRSA 2022).

In 2022/23, fishing was conducted over 319 vessel-nights, comprising 81% of the 392 TACE, which included 390 vessel-nights for the 2022/23 season and an additional 2 vessel-nights carried over from the 2021/22 season. A total of 83 pre-Christmas vessel-nights were fished. The total commercial catch of Western King Prawn in the GSVPF in 2022/23 was 152.0 t, with an additional 4.8 t taken in surveys. The 2022/23 commercial catch is 9.7% higher than recorded in 2021/22 (138.5t) but is the fifth lowest and 28% below the mean annual catch recorded since 2000/01.

Estimates of standardised FIS CPUE have remained above the target reference point (TargRP; 22.2 kg/trawl-shot) in 14 out of 18 years since 2004/05. Since 2018/19,

standardised FIS CPUE has declined and was below the TargRP between 2020/21 and 2022/23. The 2022/23 estimate of 21.3 [17.0–26.4, 95% Confidence Intervals (CI)] kg/rawl-shot is the second lowest estimate on record but 15.1% above the trigger reference point (TrRP; 18.5 kg/rawl-shot).

Estimates of standardised annual commercial CPUE declined since the fishery reopened in 2014/15 but remained between 43–56% above the TargRP of 738 kg/vessel-night between 2015/16 and 2019/20. In the last three seasons, standardised annual commercial CPUE was <15% above the TargRP. The 2022/23 estimate of 832 [781–886, 95% CI] kg/vessel-night, is a 4% increase since 2021/22 (799 [751–849, 95% CI] kg/vessel-night) and 12.7% above the TargRP (PIRSA 2022).

The decreasing trends in prawn size estimated from the FISs and commercial prawn-grade data since 2014/15 are indicative of changes in the stock size-structure of Western King Prawns in GSV and that prawns are now being harvested at a smaller average size than that which produces maximum yield per recruit. Spatial representation of the FIS data supports the steady decrease in the average size (prawns per kg, PPKG) of prawns across the survey area since 2014/15. Since 2018/19, a relatively low percentage of survey sites (<10%) have been characterised by prawn aggregations considered within the 'fishable' criteria for catch rate and size of ≥ 30 kg/rawl shot and ≤ 32 prawns/kg, respectively. Over the same period, the percentage of small (21/30, 30+ prawns per pound) and medium prawns (16/20 prawns per pound) in the commercial catch has increased. In 2022/23, small and medium prawns comprised 40% of the total catch, which is 15% more than when the fishery reopened in 2014/15.

The smaller size-structure of the Western King Prawns stock in GSV, coupled with the historically low catches and estimates of FIS CPUE and standardised commercial CPUE in recent seasons, signal a recent period of stock decline and reduced fishery performance relative to when the fishery reopened in 2014/15. Recent poor economic performance in the fishery is reflected also in the net economic return being negative in 2019/20 (-\$1 million), 2020/21 (-\$1.4 million) and 2021/22 (-\$0.4 million; BDO EconSearch 2023).

Despite these trends, the 2022/23 estimates of standardised FIS CPUE and standardised commercial CPUE are both above the TrRP for these performance indicators (PIRSA 2022). Consequently, when the two performance indicators are applied in the decision rules within the harvest strategy to determine the status of the Western King Prawn stock in GSV (Table 6), the stock is classified as '**sustainable**'.

4.3. Future research needs

The relatively low catches and estimates of FIS CPUE and standardised commercial CPUE recorded in recent seasons, signal a recent period of stock decline and reduced fishery performance relative to when the fishery reopened in 2014/15. Such trends may be expected following a period of closure where the stock rebuilds to support high catch rates immediately after re-opening, and the current harvest strategy allows catch rates to decrease without triggering the relatively large reductions in effort (nights) applied under the previous harvest strategy (PIRSA 2017, 2022). As a result, the latest harvest strategy allows relatively higher levels of effort and catch (exploitation) to be applied under lower estimates of standardised FIS CPUE and commercial CPUE.

This approach is different to those undertaken previously in the fishery and acknowledges: 1) historical fluctuations in catch and CPUE linked to variations in recruitment; 2) industry concerns relating to the inability of a relatively small fleet to locate areas of high prawn abundance; and 3) economic fishing limits being reached before stock sustainability is compromised. However, how the new harvest strategy may ultimately affect recruitment is unknown and it is recommended that the effectiveness of the harvest strategy be reviewed within three years after its implementation (2025). This approach was supported by an external review of the proposed harvest strategy (Smith, unpublished report, 2021).

The continuing trends in decreasing prawn size across the fishery indicate that yield per recruit and economic return is potentially sub optimal. Considering the relatively higher prices fetched by prawns in larger size-grades (e.g., >45% difference between U10 and 16/20 grade, GSV PBOA unpublished data – April 2023 survey prices), further analyses are required to understand the costs/benefits of targeting certain size criteria of prawns through at-sea fishing strategies. The bioeconomic model developed for the GSVPF could be updated to address this knowledge gap and used to test scenarios that could reverse recent annual negative net economic returns in the GSVPF (BDO EconSearch 2023).

The removal of the FRI from the harvest strategy decision rules in the 2022 management plan reflects the absence of a clear stock recruitment relationship. More research is required to understand spatial and temporal patterns of recruitment in GSV and could be coupled with assessment of how different at-sea fishing strategies aimed at maximising economic yield may affect recruitment. To achieve this, a better understanding is required of how recruitment is affected by the interaction between oceanographic patterns and fishing patterns during the main spawning period (November–December). A biophysical model was previously developed for the Spencer Gulf Prawn Fishery to predict patterns of larval dispersal and settlement by coupling knowledge of the biology and behaviour of Western King Prawn larvae to a hydrodynamic model (McLeay *et al.* 2015). A similar

model could be beneficial to the GSVPF to simulate how spatial changes in fishing and/or environmental conditions could maximise both recruitment and catch during parts of the fishing season when catch value is highest (e.g., pre-Christmas). The fishery would also benefit from research that focusses on bycatch monitoring (including TEPS), product value adding, trawl-gear efficiency experiments and assessing the impacts of climate change (PIRSA 2022).

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6. APPENDICES

Appendix 1. Monthly distribution of commercial (and survey) catch in the Gulf St Vincent Prawn Fishery from 1989/90–2022/23.

Season	Nov	Dec	Feb	Mar	Apr	May	Jun	Jul	Total
1989/90	35.8	9.4	-	47.8	33.6	42.3	-	-	168.8
1990/91	-	5.3	-	48.0	36.0	31.9	13.1	-	134.3
1991/92	-	-	-	-	-	-	-	-	-
1992/93	-	-	-	-	-	-	-	-	-
1993/94	-	-	-	97.9	69.3	41.2	17.0	-	225.4
1994/95	-	-	26.0	60.9	52.4	8.0	-	-	147.3
1995/96	30.7	48.3	-	65.5	46.4	67.1	-	-	258.0
1996/97	37.9	25.7	-	34.8	41.9	45.0	24.7	-	209.9
1997/98	43.8	31.7	15.8	81.3	53.7	40.5	-	-	266.9
1998/99	69.8	30.5	-	65.6	99.7	48.1	22.5	-	336.2
1999/00	19.3	82.6	27.3	71.0	76.3	91.7	32.0	-	400.2
2000/01	65.9	60.6	-	84.3	86.9	72.4	14.8	-	384.9
2001/02	8.8	94.0	-	58.5	80.6	62.1	18.1	-	322.1
2002/03	4.0	60.1	11.5	72.8	46.6	37.0	-	-	231.9
2003/04	-	13.9	-	28.9	69.5	57.7	2.5	-	172.5
2004/05	-	43.5 (2.0)	-	50.1 (2.4)	40.9 (2.0)	46.7 (2.4)	27.2	-	208.4 (8.8)
2005/06	-	21.2 (1.9)	-	13.6 (2.5)	64.1 (3.6)	40.4 (2.5)	35.5	-	174.9 (10.5)
2006/07	-	26.5 (1.6)	-	51.5 (2.9)	86.1 (3.7)	45.3 (4.5)	-	-	209.4 (12.7)
2007/08	-	30.2 (2.5)	-	63.5 (3.3)	69.6 (4.2)	65.8 (4.5)	-	-	229.0 (14.4)
2008/09	36.5	(3.2)	-	56.3 (4.0)	53.1 (4.1)	126.7 (4.1)	-	-	272.6 (15.4)
2009/10	-	31.4 (2.3)	-	24.7 (2.6)	109.2 (4.3)	58.3 (3.9)	-	-	223.6 (13.0)
2010/11	-	31.9 (2.5)	-	6.9 (2.9)	43.3 (3.0)	68.5 (2.6)	27.6	-	178.3 (11.0)
2011/12	16.0*		-	25.0	38.0 (2.0)	37.2 (2.1)	8.8*		125.0 (4.2)
2012/13	-	-	-	-	-	-	-	-	-
2013/14	-	-	-	-	-	(1.9)	-	-	(1.9)
2014/15	40.7	16.4	-	65.9	56.8	44.5 (2.8)	25.2*		249.4 (2.8)
2015/16	20.1*		-	54.4	49.8	32.4 (4.1)	42.7	18.4	217.8 (4.1)
2016/17	21.2	24.6	-	29.8	40.2	49.3 (2.9)	59.4*	-	224.6 (2.9)
2017/18	58.0*		-	25.2	60.0	49.2 (3.5)	44.3*	-	236.6 (3.5)
2018/19	17.6	25.9	-	25.0	52.2	32.0 (2.5)	43.0	16.5	212.2 (2.5)
2019/20	38.7*		-	30.8	33.2	17.5 (2.0)	12.2*		132.3 (2.0)
2020/21		11.5	-	26.8	27.3	18.3 (2.2)	20.5	5.0	109.3 (2.2)
2021/22	0.3	12.9		18.8	25.7	33.9	42.0	4.9	138.5 (3.7)
2022/23	23.9	26.7		24.0	29.9	32.0	15.5*	-	152.0 (4.8)

*Data between 1989/90 and 2019/20, and 2022/23 amalgamated across more than one month due to confidentiality requirements (<5 licence holders), data from gear trials not included. Survey catches () since 2011/12 comprise catches from both T90- and diamond-mesh net.

Appendix 2. Size-grade composition (t) of annual harvests in the Gulf St Vincent Prawn Fishery from 2005/06–2022/23. Grades include; soft and broken (SB), small (S), medium (M), large (L) and extra-large (XL). Note: grade weight totals are estimated from daily fishing logbooks and are not adjusted relative to Catch Disposal Records (CDRs).

SEASON	XL	XL-Split			L	M	S	SB
		U6	U8	U10	10/15	16/20	20+	
2005/06	29.0				30.1	8.7	3.4	5.9
2006/07	46.0				53.1	26.0	6.8	9.7
2007/08	40.2				56.1	25.6	4.2	10.1
2008/09	50.4				67.6	38.4	9.7	10.4
2009/10	36.2				59.3	49.9	13.6	12.6
2010/11	26.2				42.9	43.9	12.0	7.6
2011/12	25.6				35.4	23.7	8.8	5.6
2012/13								
2013/14								
2014/15	57.1	2.5	17.8	36.8	104.8	49.1	9.1	15.9
2015/16	57.3	3.6	22.1	31.6	78.7	41.3	11.9	16.0
2016/17	53.4	3.0	18.2	32.2	88.9	40.9	9.9	14.1
2017/18	52.3	2.4	19.3	30.6	89.0	49.4	11.4	12.1
2018/19	38.7	1.9	14.9	21.9	74.9	51.5	24.1	16.6
2019/20	24.6	1.0	9.5	14.0	49.6	32.0	15.3	9.3
2020/21	17.6	0.5	6.2	10.8	38.5	26.5	15.8	10.8
2021/22	30.4	4.0	11.5	15.0	48.3	30.8	17.5	10.8
2022/23	24.1	0.7	6.0	17.3	55.5	42.4	17.2	10.8