Fisheries

Spencer Gulf Prawn *Penaeus (Melicertus) latisulcatus* Fishery

K.A. Heldt, V. Cipriani and G. E. Hooper

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

November 2025

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 provides a biennial assessment of the South Australian Spencer Gulf Prawn Fishery (SGPF) for the 2022/23 and 2023/24 fishing years.

The aims of this report were to: (i) provide brief synopses of the management of the fishery and biology of the Western King Prawn (*Penaeus* (*Melicertus*) *latisulcatus*); (ii) review the performance of the fishery; (iii) provide the current status of the resource; (iv) summarise information on by-product and bycatch; and (v) identify future research and monitoring needs.

The total harvest by the SGPF reached 1,578 t in 2022/23 and 1,465 t in 2023/24. The fleet required 48 nights (1,848 vessel-nights) in 2022/23 and 50 nights in 2023/24 (1,904 vessel-nights). These annual harvest and effort totals translated into catches per unit effort (CPUEs) in 2022/23 and 2023/24 of 91.2 and 81.9 kg h^{-1}, respectively.

Size grade composition of the annual harvest and the mean 'bucket count' per 7 kg, generally indicated a downward trend in average prawn size over the past several years, with 2020/21 and 2022/23 - 2023/24 as exceptions. The recent increases in average prawn size may in part be due to more conservative fishing strategies (i.e., prawn size criteria set at lower bucket counts) to meet the economic objectives of the fishery, and consequently further improve fishery sustainability.

After each survey, the mean survey $CPUE_{adults}$ (size grades comprising fewer than 20 prawns per pound) was assessed against lower reference points (RP_{lower}). In 2022/23 and 2023/24, the mean survey $CPUE_{adults}$ was below the RP_{lower} in November stock assessment surveys. The mean survey $CPUE_{recruits}$ in 2022/23 reduced from peaks in 2018/19 and 2019/20 but remained above the RP_{lower}. In 2023/24, the mean survey $CPUE_{recruits}$ was amongst the lowest recorded since 2004/05 and below the RP_{lower} in November and April.

The weighted mean survey $CPUE_{recruits}$ (± 95% CI), was within the 'medium' reference level ($\geq 1.09 < 2.18$ lb min^{-1}) in 2022/23 (2.09 ± 0.21 lb min^{-1}) and 2023/24 (1.22 ± 0.15 lb min^{-1}), while egg production was below the historical reference point (RP) in 2022/23 (by 12%) and slightly above the reference point in 2023/24 (by 17%). The recruitment index remained above its historical RP (2.38 lb min^{-1}; PIRSA 2014) and was 5.07 ± 0.50 lb min^{-1} and 3.89 ± 0.45 lb min^{-1} in 2022/23 and 2023/24, respectively. However, these three parameters do not have prescribed management outcomes within the current harvest strategy framework.

The weighted mean $CPUE_{adults}$ (± 95% CI) from the November, March and April surveys is the key performance indicator of relative spawning stock biomass. During 2022/23 and 2023/24, the weighted mean $CPUE_{adults}$ was 4.35 ± 0.34 lb min^{-1} and 4.20 ± 0.34 lb min^{-1}, respectively, both of which are above the trigger reference point (TRP; 3.16 lb min^{-1}). Under the definition in the harvest strategy, the stock is classified as '**sustainable**'.

Recent bycatch surveys provided estimates of abundance and biomass for 20 species of interest in the SGPF. The latest survey also indicated a reduction in the apparent discrepancy in the reporting of Syngnathids between surveys and fishing (i.e. reduced underreporting occurring during commercial fishing). In future, it will be important to continue a combination of ongoing survey monitoring, education awareness on threatened, endangered, or protected species (TEPS) reporting requirements, and additional spatial and temporal comparison of reporting rates.

Future research needs will primarily be focused on continuing investigation of the effectiveness of artificial light (Light Emitting Diode, LED) in reducing finfish bycatch without prawn loss (FRDC 2023-039), revising and/or augmenting bycatch monitoring programs, as needed, to meet the requirements of Marine Stewardship Council (MSC) v3.1, and identifying whether key environmental drivers in Spencer Gulf can be used to inform management practices in the SGPF.

Key fishery performance and fleet metrics are summarised as follows:

Spencer Gulf Prawn Fishery		
Year	2022/23	2023/24
Status	**Sustainable**	**Sustainable**
Indicator	Survey $CPUE_{adults}$	Survey $CPUE_{adults}$
Survey $CPUE_{adults}$	4.35 lb min-1	4.20 lb min-1
Total harvest	1,578 t	1,465 t
Total effort	17,304 h	17,889 h
Commercial CPUE	91.2 kg h^{-1}	81.9 kg h^{-1}
Number of licenses/vessels	39	39
Nights fished	48 (fleet) 1,848 (vessel-nights)	50 (fleet) 1,904 (vessel-nights)

Keywords: Western King Prawn, *Penaeus* (*Melicertus*) *latisulcatus*, fishery stock assessment, stock status, catch per unit effort (CPUE).

1. INTRODUCTION

1.1. Background

Stock assessment reports for the Spencer Gulf Prawn Fishery (SGPF) have been updated annually and/or biennially since 2003 as part of the South Australian Research and Development Institute (SARDI) Aquatic and Livestock Sciences' ongoing assessment program (Carrick 2003; Dixon et al. 2005, 2007; Dixon and Hooper 2008; Dixon et al. 2009, 2010, 2012, 2013; Noell et al. 2014; Noell and Hooper 2015, 2017, 2019, 2021; Heldt and Hooper 2023).

1.2. Objectives

This report updates the last assessment (Heldt and Hooper 2023) with information obtained for the 2022/23 and 2023/24 fishing years and provides: (i) a review and update of the biology of the Western King Prawn; (ii) analyses of survey data; (iii) analyses of commercial catch and effort data, including trawl footprint estimates; (iv) evaluation of fishery performance with respect to fishing strategies and biological performance indicators in the Management Plan; (v) end-of-year stock status determinations; (vi) a by-product and bycatch summary; and (vii) recommendations for future research.

1.3. Description of the fishery

1.3.1. Fishery location

In South Australia, there are three commercial prawn fisheries: (i) SGPF; (ii) Gulf St Vincent Prawn Fishery (GSVPF); and (iii) West Coast Prawn Fishery (WCPF). All exclusively target the Western King Prawn (*Penaeus* (*Melicertus*) *latisulcatus*). The SGPF is the largest in terms of total area (22,367 km^2), production (latest 10-year mean: 1,820 t), and number of licence holders/vessels (39).

The SGPF encompasses the waters of Spencer Gulf north from Cape Catastrophe, Eyre Peninsula (34°59.060′S, 136°00.130′E) to Cape Spencer, Yorke Peninsula (35°17.993′S, 136°52.835′E). It comprises ten regions that represent the main trawl grounds of the fishery. These regions are subdivided into a total of 125 commercial fishing blocks (Figure 1.1).

South Australia's prawn fisheries are the only substantial single-species prawn fisheries in Australia. However, it is not the only fishery to target the Western King Prawn. In 2022, the Western King Prawn was also targeted and harvested by Western Australia's Shark Bay

(503 t, the lowest catch recorded in over 40 years) and Exmouth Gulf (218 t) prawn fisheries, respectively (Wilkin et al. 2023a; 2023b).

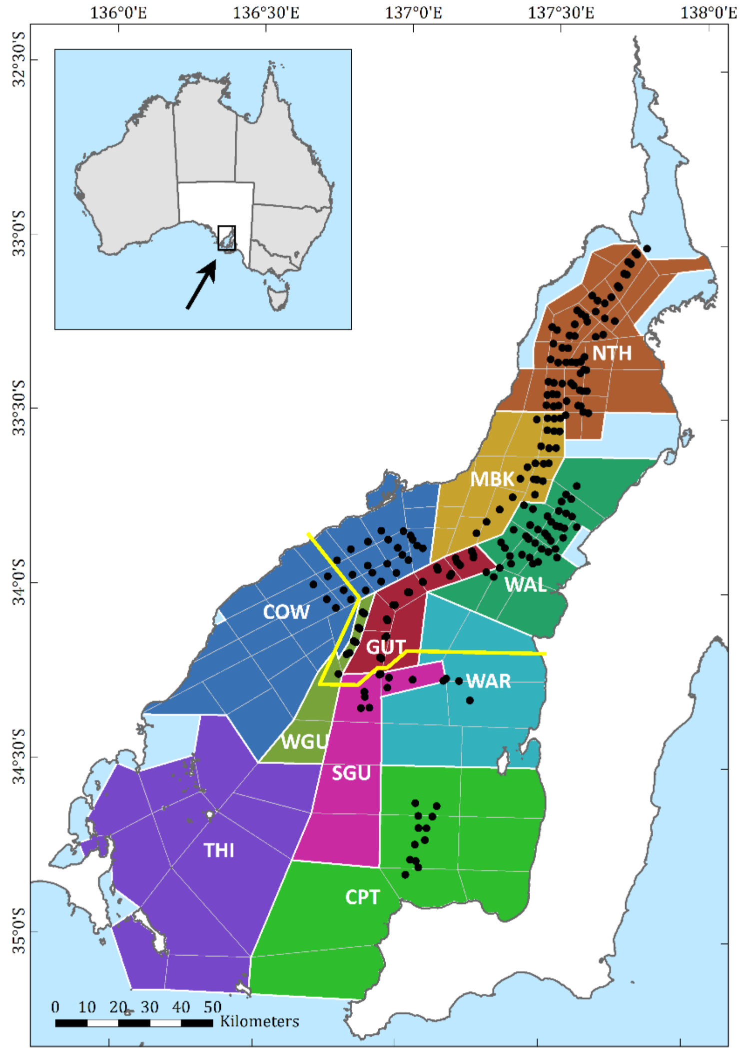

Figure 1.1. Stock assessment historical survey locations (black symbols), fishing blocks and regions of the Spencer Gulf Prawn Fishery. Inset map shows location of the fishery in South Australia. Also shown is the Mid/North–Southern Gulf boundary (yellow line) used in fishing strategy development (see Section 1.8.4). Region abbreviations: COW, Cowell; CPT, Corny Point; GUT, Gutter; MBK, Middlebank/Shoalwater; NTH, North; SGU, South Gutter; THI, Thistle; WAL, Wallaroo; WAR, Wardang; WGU, West Gutter.

1.3.2. *The Spencer Gulf environment*

Spencer Gulf is a large shallow body of water with a mean depth of 23 m, and a maximum depth of 87 m at its entrance in the south. The predominant sediment is sand and mud with seagrass habitats common at depths less than 10 m. Spencer Gulf is situated in a semi-arid climate where annual evaporation far exceeds precipitation. Due to excessive evaporation, the gulf is classified as an inverse estuary, attaining salinities that are greater than the surrounding ocean with salinity increases towards the head of the gulf (Nunes and Lennon 1986). Inverse estuaries are further characterised by an outflow of dense, saline water in bottom layers and an inflow of oceanic water in surface layers. This density-driven circulation is influenced by the Earth's rotation, such that the dense saline outflows occur along the eastern side, whereas surface inflows occur along the western side (Kämpf et al. 2009). This gives rise to an overall clockwise circulation pattern.

Sea surface temperatures (SSTs) in the South Australian gulfs are lower and more variable than in northern fisheries that target the Western King Prawn (e.g. Broome and Shark Bay in Western Australia; Noell and Hooper 2021). In Spencer Gulf, SST fluctuates seasonally between ~12°C and ~24°C (Nunes and Lennon 1986) and, in summer months, is characterised by warmer surface waters in the north, cooler surface waters in the south, and considerably lower temperatures in the surrounding open ocean (Bierman et al. 2009). Additionally, in the past two decades, Spencer Gulf has been 1.6 °C and 0.8 °C warmer in the northern and southern regions of the gulf, respectively (Bailleul and Doubell 2024).

1.3.3. Nursery areas

In South Australian waters, juvenile prawns occur predominantly on intertidal sand and mudflats, generally located between shallow subtidal/intertidal seagrass beds and mangroves higher on the shoreline (PIRSA 2003). In Spencer Gulf, the density of juveniles is greater in the mid-intertidal zone compared to lower and upper zones (Roberts et al. 2005), while in Gulf St Vincent, densities of juveniles are similar across the intertidal zones (Kangas and Jackson 1998).

Based on Bryars' (2003) inventory of important coastal fishery habitats in South Australia, Dixon et al. (2013) estimated that 76% of the Spencer Gulf coastline comprises appropriate habitat for prawn nursery areas (i.e., tidal flat only, 51%, and mangrove forests[1], 25%) (Table 1.1). Most of these habitat types are in upper Spencer Gulf. Surveys of juvenile prawns have shown that greatest abundances generally occurred at sites within this region (Roberts et al. 2005).

[1] Mangrove forest always overlapped with tidal flat but is considered separate to habitat comprising only tidal flat.

Table 1.1. Fishery habitat areas and the estimated distance and proportion of coastline of tidal flat and mangrove forest for each of South Australia's prawn fisheries.

Fishery	Fishery habitat areas	Coastline (km)	Tidal flat only		Mangrove	
			km	%	km	%
Spencer Gulf	15	992	508	51	245	25
Gulf St Vincent	11	551	225	41	79	14
West Coast	16	1310	310	24	45	3

In a study of penaeid prawn fisheries around the world, Pauly and Ingles (1999) demonstrated a significant relationship between mangrove area and fisheries production, thus supporting the widely held view that intertidal vegetation (particularly mangroves) plays a major role in penaeid prawn recruitment.

1.3.4. *Commercial fishery*

Prawns are harvested at night using demersal otter trawls configured with two nets (Figure 1.2). It has become standard practice in the fishery to use 'crab bags' to exclude bycatches of Blue Swimmer Crabs (*Portunus armatus*) and mega-fauna (Figure 1.3), 'hoppers' for efficient sorting of the catch and rapid return of bycatch to the sea (Figure 1.2), and 'graders' to sort the prawns into marketable size categories (Figure 1.2). All vessels operating in the SGPF process and freeze the catch on-board prior to landing.

The SGPF is the third most valuable prawn fishery in Australia ($26.5M in 2022/23; BDO EconSearch 2024a) behind the Commonwealth's Northern Prawn Fishery (NPF; $112.4M in 2022/23; Butler et al. 2024) and the Queensland's East Coast Otter Trawl Fishery ($111.3M in 2021/22; BDO EconSearch 2024b). The SGPF has 39 licences in the fishery, and the value per licence holder is estimated (by operators) at ~$4.1M per licence (BDO EconSearch 2024a).

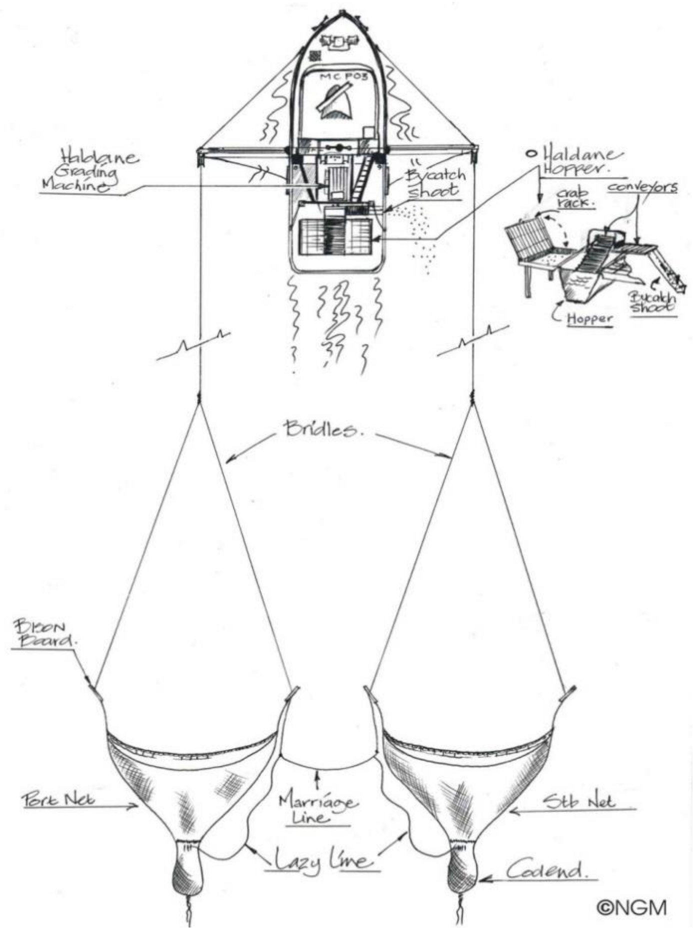

Figure 1.2. Double rig trawl net configuration, hopper and size grader used in the Spencer Gulf Prawn Fishery. Source: Carrick (2003).

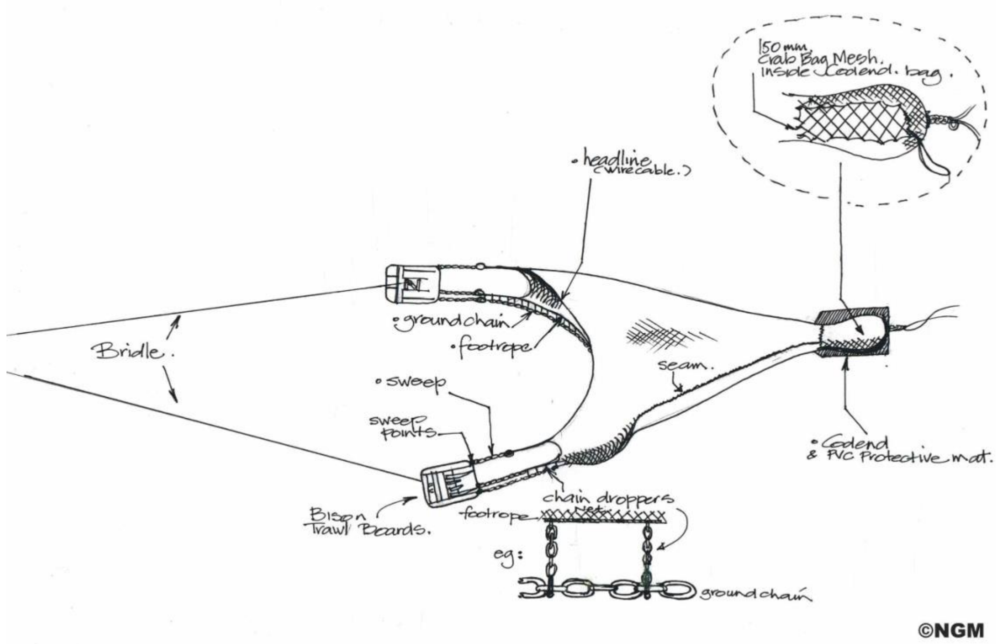

Figure 1.3. Trawl net configuration showing trawl boards, head rope, ground chain and cod end with crab bag. Source: Carrick (2003).

1.3.5. *Recreational, traditional and illegal catch*

Under current fisheries legislation, it is prohibited for any person to take Western King Prawns from waters less than 10 m in depth. As prawn trawl nets can only be used by the commercial fishing sector, the catch by the recreational sector and Aboriginal traditional fishing is negligible (Anon. 2003; Beckmann et al. 2023). The illegal take of prawns is also assumed to be negligible.

1.4. Management of the fishery

1.4.1. *Legislation*

The SGPF is managed by the Department of Primary Industries and Regions (PIRSA) Fisheries and Aquaculture in accordance with the 'Management Plan for the South Australian Commercial Spencer Gulf Prawn Fishery' (PIRSA 2020; hereafter referred to as the 'Management Plan') and legislative framework provided within the *Fisheries Management Act 2007*, *Fisheries Management (General) Regulations 2017* and *Fisheries Management (Prawn Fisheries) Regulations 2017*.

1.4.2. *Current management arrangements for the commercial sector*

Management arrangements for the SGPF have evolved since the fishery began in the late 1960s (Table 1.2). Now, the SGPF is a limited entry fishery with 39 licensed operators. Trawling activity is prohibited during daylight hours and in waters less than 10 m in depth. Effort is restricted by spatial and temporal closures, vessel size and power, and configuration of trawl gear (including type and number of nets towed, maximum headline length and minimum mesh size) (

Table 1.3).

For the purpose of this report, the 'fishing year' (fyear) is defined as the 12-month period from 1 October to 30 September the following year. However, fishing generally only occurs during the months of November and December and from March to June between the last and first quarter of the moon (i.e., during waning crescent and waxing crescent phases either side of the dark moon). The areas opened to fishing are co-managed by PIRSA Fisheries and Aquaculture and the 'Coordinator-at-Sea' appointed by the Spencer Gulf and West Coast Prawn Association (SGWCPA) under Regulation 10 of the *Fisheries Management (Prawn Fisheries) Regulations 2017*.

Table 1.2. Key management milestones over the history of the Spencer Gulf Prawn Fishery. Adapted from PIRSA 2020. * Denotes industry implemented closures (K. Pyke-Tape, pers. comm.)

Year	Management milestone
1968	Licences restricted; trawling prohibited in waters <10 m; Commercial catch and effort recording began
1969	*Prawn Resources Regulations 1969* established; Spencer Gulf divided into two zones.
1971	Spencer Gulf zones removed
1973	Spatial closure north of Point Lowly introduced*
1975	Licences restricted to 39
1981	Spatial closure adjacent to Port Broughton*
1982	*Fisheries Act 1982* introduced
1984	*Scheme of Management (Spencer Gulf Prawn Fishery) Regulations 1984* introduced
1991	*Fisheries (Scheme of Management – Prawn Fisheries) Regulations 1991* introduced
1995	*Fisheries (Management Committees) Regulations 1995* introduced
1998	First management plan implemented
2000	Spatial closure of waters adjacent Shoalwater/Cowell*
2002	Spatial closure of waters adjacent to Wardang Island to Corny Point*
2006	*Fisheries Management (Prawn Fisheries) Regulations 2006* introduced
2007	Second management plan implemented (Dixon and Sloan 2007); *Fisheries Management Act 2007* introduced
2014	Third management plan (PIRSA 2014) implemented
2017	Fisheries Management (Prawn Fisheries) Regulations 2017 introduced; Corny Point spatial closure*
2018	Spatial closure at Arno Bay, Wallaroo, and Port Broughton reefs*
2020	Fourth management plan implemented (PIRSA 2020; prior to the 2020/21 fishing year)
2024	Commenced transition from paper logbooks to electronic reporting of commercial fishing data

Table 1.3. Current management arrangements for the Spencer Gulf Prawn Fishery.

Management control	Specification
Target species	Western King Prawn (*Penaeus* (*Melicertus*) *latisulcatus*)
Permitted by-product species	Eastern Balmain Bug (*Ibacus* spp.), Southern Calamari (*Sepioteuthis australis*)
Limited entry	Yes
Number of licences	39
Corporate ownership of licences	Yes
Licence transferability	Yes
Minimum depth for trawling	10 m
Method of capture	Demersal otter trawl
Trawl net configuration	Single or double rig (double rig exclusively used)
Maximum total headline length	29.26 m
Minimum mesh size	4.5 cm
Maximum length of vessel	24 m
Maximum engine capacity	340 kW
Catch and effort data	Daily logbook, submitted monthly
Recreational fishery	Restricted to depths ≥10 m; hand nets only

1.5. Biology of the Western King Prawn

1.5.1. *Distribution*

The Western King Prawn is distributed throughout the Indo-west Pacific (Grey et al. 1983). Over the last decade, *P. latisulcatus* has established itself as a Lessepsian migrant along the Egyptian Mediterranean coast, becoming a highly exploited species (El-Deeb et al. 2022). Being predominantly tropical, it typically inhabits waters ranging from 22–30°C. However, its distribution in South Australia is unique, occurring at the lower limits of its thermal tolerance (~12–24°C), restricted to relatively warmer waters of Spencer Gulf, Gulf St Vincent and along the West Coast (Roberts et al. 2012). Several authors have provided detailed accounts of this species' distribution in Spencer Gulf (King 1977; Sluczanowski 1980; Carrick 1982, 1996). The Western King Prawn is a benthic species that prefers sandy areas to seagrass or vegetated habitats (Tanner and Deakin 2001, Bryars 2003). Juvenile and adult prawns show a strong diel behavioural pattern of daytime burial and nocturnal activity (Rasheed and Bull 1992; Primavera and Lebata 2000). Strong lunar and seasonal differences in activity are also exhibited, where prawn activity (and catchability) is greater during the new (dark) moon phase of the lunar cycle and warmer months.

1.5.2. *Length-weight relationship*

The relationship between carapace length (L, mm) and weight (W, g) for the Western King Prawn from Spencer Gulf is described by a power function (males: $W = 0.00124\ L^{2.76}$; females: $W = 0.00175\ L^{2.66}$; Carrick 2003).

1.5.3. *Reproductive biology*

In Spencer Gulf, adult Western King Prawns aggregate, mature, mate and spawn in deep water (>10 m) between October and April, with the main spawning period being earlier in the fishing year (October to January), and peaking in November (SARDI, unpublished data; Hackett 2017). While the water temperature range of 17–25°C for spawning of Western King Prawn (Penn 1980; Courtney and Dredge 1988) generally occurs from November to May in Spencer Gulf, most spawning in the gulf is restricted to earlier in the fishing year. This is likely to be associated with optimising reproductive success from shorter larval durations and higher larval survival at that time of year (Roberts et al. 2012).

The proportion of female Western King Prawns in Spencer Gulf attaining maturity (P) increases as a function of carapace length as described by a logistic model ($P = 8.3\times10^{-6} + [1/(1+e^{-0.277(L-36.45)})]$), with the size-at-maturity (L_{50}) estimated between 36.5 mm (Carrick 2003) and 42 mm (Hackett 2017). More recently, Hackett (2017) reported that fecundity in Western King Prawns ranges from 40,000 to 207,000 eggs per gram of body weight for individuals with carapace lengths between 21 mm and 61 mm. The study also determined that the mean number of oocytes per gram of ovary tissue in ripe females is 100,992 ± 5,073. Based on this, fecundity ranges from 9,423 to 567,600 eggs across this size range. Additionally, gonadosomatic index (GSI) and ovary weight both show a positive correlation with carapace length, indicating that larger prawns tend to be more fecund and are more likely to produce higher egg quantities.

Spawning frequency for the Western King Prawn appears to be related to moulting frequency, indicating that multiple spawning events occur within a season, and females are likely to spawn over multiple seasons (Penn 1980).

1.5.4. Larval and juvenile stages

The life cycle of the Western King Prawn consists of an offshore phase, where spawning of adults and drift and growth of larvae occurs, and an inshore phase, where settlement of post-larvae and growth through to the juvenile stage occurs. Post-larvae produced from early in the spawning period (i.e., October/November), settle in inshore nursery areas at a carapace length of 2–3 mm during December or January before emigrating to deeper water in May or June (Carrick 1996). Alternatively, post-larvae produced from spawning after January settle in nurseries from March, grow slowly, then 'over-winter' in the nursery areas before recruiting to the trawl grounds in February of the following year (Carrick 2003).

Temperature, salinity and food availability are generally considered to have the most influence on larval growth and survival in penaeid prawns (Preston 1985; Carrick 2003; Jackson and Burford 2003). Larval rearing experiments have demonstrated that an increase in temperature over a range of 17–25 °C resulted in an increase in growth rate, shorter larval period and an increase in larval survival for Western King Prawn (Roberts et al. 2012; Rodgers et al. 2013), thus demonstrating the strong tropical affinity of this species.

1.5.5. Stock structure

While the South Australian Museum found significant genetic differences between South Australian and Western Australian Western King Prawn samples (cited in Carrick 2003), Richardson (1982) found no evidence of genetic isolation among South Australian populations. Notwithstanding the possibility that South Australia's prawn fisheries may comprise a single stock, they continue to be managed as three separate units based on historic arrangements.

1.5.6. Growth

Prawns undergo a series of moults to increase their size incrementally. The shedding of hard body parts during moulting means that the age of individuals cannot be reliably determined. Instead, tag-recapture studies for the Western King Prawn in Spencer Gulf indicate strong seasonal growth, with maximum growth rates for both sexes occurring in early March, and little or no growth from late July to mid-October for males and from late August to late September for females (Carrick and Ostendorf 2005).

1.5.7. *Movement*

Using the same tag-recapture data as those for describing growth, Carrick (2003) described three general movement patterns of the Western King Prawn in Spencer Gulf: (i) north to south movement in northern Spencer Gulf; (ii) east to northeast movement from northern Cowell and the top of the Gutter; and (iii) southeast movement from southern Cowell and the Gutter towards Corny Point (Figure 1.1).

1.6. Research program

The SARDI stock assessment program has been supplemented with research on early-life history (Carrick 1996; Tanner and Deakin 2001; Roberts et al. 2005, 2012; Rodgers et al. 2013), population dynamics and fisheries modelling (King 1977; Sluczanowski 1984; Carrick and Ostendorf 2005; McLeay et al. 2015; Noell et al. 2015), gear selectivity (Dixon et al. 2014; Kennelly and Broadhurst 2014; Noell et al. 2018), catch rate standardisation (not currently in use; Noell and Hooper 2021), and bycatch and ecosystem-based assessments (Svane et al. 2009; Currie et al. 2011; Mayfield et al. 2014; Burnell et al. 2015; Noell 2017; Heldt and Hooper 2023).

In 2015/16, the frequency of stock assessment reports for the SGPF changed from annual to biennial. This provided opportunities for other research to be undertaken in alternate years. Given that stock status is determined before the start of each fishing year, a biennial stock assessment program was 1) considered to be a cost-effective approach and 2) facilitated undertaking research on the fishery’s other needs and interests, without compromising the main objective of determining the annual status and harvest strategy for the following year.

This stock assessment report summarises information from the biennial stock assessment program that comprises seven components: (i) a review and update of the biology of the Western King Prawn; (ii) analysis of survey data; (iii) analysis of commercial catch and effort data, including trawl footprint estimates; (iv) evaluation of fishery performance with respect to fishing strategies and biological performance indicators in the Management Plan; (v) end-of-year stock status determinations; (vi) a by-product and bycatch summary; and (vii) recommendations for future research.

1.7. Information sources

1.7.1. *Stock assessment surveys*

Fishery-independent stock assessment surveys are conducted three times each fishing year (i.e., October/November, February/March and April) using industry vessels, skippers and crews, with independent observers placed on each vessel, to collect information on prawn size and catch per unit effort (CPUE). The second survey was traditionally undertaken in February but, as of 2020, this survey was shifted to March to eliminate the hiatus between the survey and the March fishing run, and thereby increase the relevance of the survey result and avoid the need to undertake an additional fishery-dependent survey ('spot survey') prior to fishing.

Specific data collected include the CPUE of 'adult' and 'newly recruited' prawns (consisting of industry grades with fewer and more than 20 prawns per pound, respectively) and average prawn size (provided as a 'bucket count' of prawns that fill a 7-kg bucket) at each survey location. Importantly, these data inform the application of the harvest strategy (Section 1.8). Additionally, data from the October/November survey provides supplementary information on egg production, and data from the March survey provides information for the recruitment index (Appendix D).

The historical survey design from 2004 underwent a revision during the development of the new harvest strategy (PIRSA 2020). The current survey design was implemented at the start of the 2020/21 fishing season and comprises three stock assessment surveys with ~100–200 fixed survey locations (Figure 1.1). This survey design ensures a cost-effective and consistent spatial and temporal replication of survey shots from 2020/21 onwards to improve the robustness of surveys as a measure of relative biomass. In the harvest strategy, CPUE from each stock assessment are also weighted based on the perceived representativeness of each survey as an indicator of the relative biomass. Results from the survey inform the nature of the fishing strategy following each survey and determine the stock status at the end of the year.

Additionally, a new bycatch program was initiated in 2019/20 that measured 20 bycatch 'species of interest' as part of the October/November and February/March surveys. This new survey program is an alternative method to the previously existing gulf-wide bycatch surveys (Currie et al. 2009; Burnell et al. 2015) and provides cost-effective spatial and temporal monitoring of key bycatch species in the fishery. In general, at designated sampling locations, the numbers and weights for a subset of species were recorded in an alternative sampling sequence of crab (Blue Swimmer Crab), fish, and by-product (Southern Calamari and Eastern Balmain Bug) categories (Table 1.4). Reporting of threatened and protected species (TEPS) is mandatory, and data for these species were recorded for all sampling locations. The number of sampling locations varied slightly since conception, but in recent years bycatch has been recorded in at least 47 locations for each category. Where possible, the total number and weight for each species were recorded but, if necessary, these were estimated from subsamples. All bycatch (excluding retained by-product) was immediately discarded at sea after data were recorded. Numbers and weights were standardised to relative abundance and biomass per swept area (numbers and grams per hectare, respectively; Appendix C). The monitoring of these species was considered priority research within the context of a broader ecological monitoring program that was proposed to meet the requirements of the Marine Stewardship Council (MSC) Fisheries Standard v2.0 (SARDI 2019).

Table 1.4. Bycatch species of interest monitored in the Spencer Gulf Prawn Fishery and associated Marine Stewardship Council (MSC) criterion (SARDI 2019). Abbreviation: TEP, threatened, endangered or protected. *presumed to be primarily *Ibacus peronii*

Species	Scientific name	MSC criterion
Blue Swimmer Crab	*Portunus armatus*	Primary, Main
Southern Calamari	*Sepioteuthis australis*	Primary, Minor
King George Whiting	*Sillaginodes punctata*	Primary, Minor
Snapper	*Chrysophrys auratus*	Primary, Minor
Southern Garfish	*Hyporhamphus melanochir*	Primary, Minor
Bluefin Leatherjacket	*Thamnaconus degeni*	Secondary, Main
Skipjack Trevally	*Pseudocaranx wrighti*	Secondary, Main
Rough Leatherjacket	*Scobinichthys granulatus*	Secondary, Minor
Bluespotted Goatfish	*Upeneichthys vlamingii*	Secondary, Minor
Port Jackson Shark	*Heterodontus portusjacksoni*	Secondary, Minor
Toothbrush Leatherjacket	*Acanthaluteres vittiger*	Secondary, Minor
Eastern Balmain Bug	*Ibacus spp.**	Secondary, Minor
Tiger Pipefish	*Filicampus tigris*	TEP
Rhino Pipefish	*Histiogamphelus cristatus*	TEP
Brushtail Pipefish	*Leptoichthys fistularius*	TEP
Leafy Seadragon	*Phycodurus eques*	TEP
Common Seadragon	*Phyllopteryx taeniolatus*	TEP
Spotted Pipefish	*Stigmatopora argus*	TEP
Knifesnout Pipefish	*Hypselognathus rostratus*	TEP
Bigbelly Seahorse	*Hippocampus abdominalis*	TEP

1.7.2. Commercial logbook data

Licence holders are required to complete and submit a daily catch and effort logbook to PIRSA Fisheries & Aquaculture at the end of each month. A monthly unloading logbook is also completed to enable validation and adjustment of daily catch estimates. The data for this assessment are reported on paper logbooks; however, in 2024 the fishery commenced a transition to replacing paper logbooks with electronic logs.

Since reporting of commercial catch and effort began in 1968, there have been a few modifications to improve the information available for assessment. From July 1987, the previously used regular grid for reporting catch and effort was replaced with 125 irregularly shaped fishing blocks (Figure 1.1) ranging in size from 29–1,029 km^2 (mean: 166 km^2). These fishing blocks better reflect the fishing grounds and differences in prawn size and abundance (Carrick 2003). Other logbook reporting requirements include the exact location (GPS coordinates) for at least three trawl shots per night, a breakdown of the prawn catch by industry size-grade, and retained by-product (Southern Calamari, *Sepioteuthis australis*; Eastern Balmain Bug, *Ibacus* spp.). Commercial catch and effort data, such as annual harvests, are considered to be more of an economic indicator and are not a performance indicator in the Management Plan.

1.8. Harvest strategy

1.8.1. *Management Plan*

An important feature of the Management Plan is the harvest strategy (PIRSA 2020), which comprises a harvest decision framework that operates at three levels: (i) to determine end-of-year stock status based on a weighted mean CPUE of adult prawns from the three surveys; (ii) the development of fishing strategies following each survey; and (iii) nightly monitoring and adjustment of fishing strategies (i.e., real-time management) against prawn size and catch rate criteria.

1.8.2. *Performance indicators*

The extent to which the fishery achieves goals and objectives of the Management Plan is assessed using a combination of biological performance indicators (PIs). The primary PI, the weighted mean survey $CPUE_{adults}$ is an indicator of relative biomass and has a prescribed management outcome (i.e., stock status). Whereas the secondary PI, weighted mean survey $CPUE_{recruits}$, can only influence decisions within the parameters of the harvest strategy framework (e.g., number of fishing nights for a 'depleting/recovering' fishery; PIRSA 2020). The primary PI is evaluated against a Reference Point (RP), while the secondary PI is assessed against levels that are considered to represent low, medium, and high levels of recruits (Table 1.55). Estimates of (1) egg production and the recruitment index from the February/March survey (Appendix D) and (2) commercial CPUE are no longer biological performance indicators for the fishery and therefore do not influence decisions from within the harvest strategy (PIRSA 2020).

Table 1.5. Performance indicators and reference points/levels for the SGPF using data obtained from all three stock assessment surveys.

Reference Point	Primary Indicator weighted mean survey $CPUE_{adults}$ lb min^{-1}(kg/hr)	Reference Level	Secondary Indicator weighted mean survey $CPUE_{recruits}$ lb min^{-1} (kg/hr)
Target	4.43 (120.8)	High	≥ 2.18 (≥ 59.5)
Trigger	3.16 (86.2)	Medium	≥ 1.09 < 2.18 (≥ 29.7 < 59.5)
Limit	2.21 (60.3)	Low	<1.09 (< 29.7)

1.8.3. Stock status determination

The harvest strategy incorporates a method for determining annual stock status, with stock status classification being explicitly linked to the primary performance indicator, the weighted mean CPUE of adult prawns ($CPUE_{adults}$) obtained from the three stock assessment surveys. Weightings used for this calculation are based on the perceived representativeness of each survey as an indicator of the relative biomass and, therefore, its contribution towards an end-of-year stock status (0.20 for November, 0.35 for March and 0.45 for April). Consistent with most South Australian-managed fisheries, the stock status classification for the SGPF has been developed to align with the terminology of the national status reporting framework (i.e., 'sustainable', 'depleting' or 'recovering', or 'depleted'; Roelofs et al. 2024).

The target reference point is 4.43 lb min^{-1} (120.8 kg h^{-1}), which represents desirable fishing performance. The trigger reference point (TRP) is set at a $CPUE_{adults}$ of 3.16 lb min^{-1} (86.2 kg h^{-1}), above which the fishery is considered sustainable (the stock is considered at a level sufficient to ensure that, on average, future recruitment to the fishery will be adequate). The TRP represents the boundary between a stock being classified as sustainable or depleting/recovering. The limit reference point (LRP) is set at a $CPUE_{adults}$ of 2.21 lb min^{-1} (60.3 kg h^{-1}) and establishes a benchmark for undesirable fishery performance. In this case, the LRP for determining if a stock is depleted or not is considered to correspond to recruitment overfishing where the spawning stock biomass has been reduced so that average recruitment levels are significantly reduced.

For as long as the stock status has been determined for the SGPF, the fishery has been classified as sustainable, irrespective of the method used to determine status (i.e., historically, using multiple lines of evidence or, since 2014/15, the weighted mean of survey $CPUE_{adults}$). Associated with a sustainable stock, the harvest strategy describes a hierarchical set of fishing strategies and prawn size and catch criteria that apply in the following year, which collectively aim to maximise economic yield by limiting effort spatially and temporally. In the event that the fishery is classified as not sustainable (i.e., depleting, depleted, or recovering), the harvest strategy provides measures that aim to promote stock recovery either by restricting the number of fishing nights (under depleting or recovering classifications) or closing the fishery for the whole year (under depleted classification).

1.8.4. Fishing strategy development

The SGPF has been fished within sustainable limits or classified as a sustainable stock since the assessment program began over 20 years ago (Carrick 2003). Providing the fishery is classified as a sustainable stock, the fishing strategy is developed immediately after each stock assessment survey so that the fleet can commence fishing the next night. Based on the stock status, the season's fishing strategies are set. For example, for a sustainable stock, the development of a sustainable fishing strategy depends on the results of surveys and requires setting a catch cap, target prawn size, and/or minimum fleet catch. The survey result/fishing strategy is assessed against criteria for prawn size and nightly catch (Table 1.66), which influence the area(s) that are opened to fishing and the number of fishing nights, respectively, except during the pre-Christmas period, November and December. While areas fished in the pre-Christmas fishing period are still subject to a prawn size criterion (bucket count ≤260), it is largely influenced by a catch cap for the fleet (Table 1.77), which aims to provide a compromise between restricting harvests during the peak spawning period and taking advantage of high market prices for smaller (less fecund) prawns prior to Christmas. The criteria and decision rules applied after each stock assessment survey remain in place until the next survey is completed.

To enable real-time responses to stock assessment survey results, when a depleting/recovering or depleted fishing strategy is implemented (i.e., the stock status is depleting/recovering or depleted) the fishery may move to a new fishing strategy within season if mean survey $CPUE_{adults}$ and $CPUE_{recruits}$ is equal to or above associated reference points (RPs; Table 1.8).

Table 1.6. Fishing strategy size and catch criteria by area and month. The average fleet catch must be equal to and not less than the catch, and not greater than the bucket counts listed for areas to remain open to fishing. For the Mid/North region, an alternative option based on the previous harvest strategy (PIRSA 2014) is also presented under OR.

Area	Criteria	March/April (pre-survey)	April (post-survey)/May/June
Mid/North	7-kg bucket count	≤240	≤260
	Nightly catch (kg)	≥500	≥500
OR	7-kg bucket count	≤220	≤240
	Nightly catch (kg)	≥400	≥400
Southern	7-kg bucket count	≤260	≤260
	Nightly catch (kg)*	≥350	≥350

* Applicable over two consecutive nights, for southern area only.

Table 1.7. Decision table for determining the pre-Christmas fleet catch cap from the October/November mean survey $CPUE_{adults}$.

Survey $CPUE_{adults}$ (lb min^{-1})	Fleet catch cap (t)
<1.04	0
1.04	120
1.38	200
1.72	300
1.93	350
2.13	375
2.37	400
2.68	425
2.99	450
3.30	475
3.61	500

Table 1.8. Reference points for survey $CPUE_{adults}$ and $CPUE_{recruits}$. that are used when the stock status is depleting/recovering or depleted. The RP_{lower} for $CPUE_{adults}$ does not imply overfishing; rather, it represents the lower historic range, which is still above the sustainable limit, and can therefore be considered an economic limit. Abbreviations: RP_{lower}, lower reference point.

Survey	$CPUE_{adults}$ (lb min^{-1})	$CPUE_{recruits}$ (lb min^{-1})
	RP_{lower}	RP_{lower}
November	2.50	0.78
March	3.32	1.49
April	4.55	1.41

The fishing strategy is considered to generally reflect the status of the resource, and their criteria are devised to ensure that catch and effort levels are appropriate to ensure sustainability. For example, a low mean survey $CPUE_{adults}$ indicates a low relative biomass of targeted prawns and may lead to more conservative decisions within the current criteria (e.g., either avoiding fishing or limiting the number of nights in certain areas with excess small prawns), which aims to increase $CPUE_{adults}$ back to historic levels. During the fishing period, the industry 'Committee-at-Sea' (CAS) monitors the catch of the fleet with respect to size and catch criteria of the fishing strategy. In addition, where necessary, or when the CAS determines it is in the interests of longer-term yields for the fishery, the CAS will reduce the size of the area fished, postpone fishing, or cease fishing altogether.

2. METHODS

2.1. Stock assessment surveys

2.1.1. *Data collection*

Three annual stock assessment surveys were undertaken in November, March, and April over one or two consecutive nights around the new moon using commercial trawlers (with an independent observer onboard). Each survey involved 30-minute trawl shots along a predetermined path at fixed locations distributed throughout the gulf (~200 for November and March surveys and ~100 for the April survey). The distance trawled at each location was dependent on trawl speed (3–5 knots), which is influenced by vessel power, tide, and weather conditions. Data collected at each location included total catch, catch of '20+' grade prawns (more than 20 prawns per pound; generally referred to as 'recruits'), number of nets used, trawl duration, tide direction, and number of prawns in a 7-kg bucket (referred to in the industry as a 'bucket count' and used as a rapid measure of average prawn size). Mean $CPUE_{adults}$ and mean $CPUE_{recruits}$ were calculated for each survey. Egg production was modelled using biological data collected from October/November surveys, and a supplementary index of recruitment was determined as the mean $CPUE_{recruits}$ from 34 locations in the upper gulf during the February/March survey (Appendix D). During the November and March surveys, at designated sampling locations, information was recorded on the numbers and weights for a subset of bycatch species and for all by-product and TEPS species (as described in Advice Notes to PIRSA Fisheries and Aquaculture on 23 August 2024).

2.2. Commercial fishing logbook data

2.2.1. *Catch, effort and CPUE*

Catch and effort data were obtained from two sources: (i) annual (1968–1973) and monthly data (January 1973–June 1988) from South Australian Fishing Industry Council (SAFIC) annual reports; and (ii) daily and monthly data (July 1988–June 2024) from catch and effort logbooks. Estimated prawn catch for each trawl shot was adjusted using validated catches reported in monthly unloading logbooks.

Catch and effort data are presented temporally (fishing year and month) and spatially (region, as defined in Figure 1.1). Catch is also presented for the early spawning period (October to December) compared to all other fishing months. Commercial CPUE was calculated by dividing the adjusted catch by effort and expressed in kg h^{-1} (unlike the survey CPUE, which is conventionally given in lb min^{-1} because of the marketing of size grades in number of prawns per pound).

2.2.2. *Prawn size*

Information on prawn size was obtained from industry size-grade data for fishing years 1997/98 and 2002/03–2023/24. Industry size grades generally refer to the number of prawns per pound (e.g., ‘U10’ means fewer than 10 prawns per pound). Since 2002/03, up to 24 size grades have been used to describe the size of prawns in the commercial catch due to different marketing practices among the industry. To ensure consistent interpretation of prawn size, size grades were converted to broader size categories of extra-large (XL), large (L), medium (M), and small (S) (

Table 2.1). For analysis of trends within years, a fifth category, soft and broken (S&B), was established for prawns that were not graded.

Prawn size was also examined in terms of bucket count based on median values estimated for each size grade (e.g., ‘10/15’ grade was estimated at 12.5 prawns per pound or 193 prawns per 7-kg bucket) (

Table 2.1). The mean nightly bucket count ($\overline{B}$) for the fleet was calculated from the grade weights provided in commercial logbooks and the median bucket count for each grade using the equation:

$$\overline{B} = \frac{\sum_{j=1}^{39}\left(\sum_{i=1}^{24}(W_i \times B_i)\right)_j}{\sum_{j=1}^{39}\left(\sum_{i=1}^{24}W_i\right)_j}$$

where *W* and *B* are grade weight and 7-kg bucket count, respectively, for grade *i* and vessel *j*.

Mean annual bucket count ($\overline{B_Y}$) was calculated using the equation:

$$\overline{B_Y} = \frac{\sum_{i=1}^{k}\left(C_i \times \overline{B_i}\right)}{\sum_{i=1}^{k}C_i}$$

where *C* is the total catch by the fleet on night *i* of a fishing year that comprises *k* nights.

Table 2.1. Conversion of industry grades reported in commercial logbooks to broader categories for analysis. Also shown for each grade is the estimated median bucket count (prawns per 7-kg bucket). -, not applicable.

Broad size category	Industry size grades reported in logbook	Median bucket count
Extra-large (XL)	‘U6’	92
	‘XL’	100
	‘U8’	108
	‘U10’, ‘L’	139
Large (L)	‘9/12’	162
	‘U12’	169
	‘LM’, ‘10/15’	193
	‘13/15’	216
	‘10/20’ (50%), ‘12/18’ (50%)	231
Medium (M)	‘10/20’ (50%), ‘12/18’ (50%)	231
	‘M’, ‘16/20’	277
	‘15/25’ (50%)	308
Small (S)	‘15/25’ (50%)	308
	‘SM’, ‘19/25’	339
	‘21/25’	354
	‘S’, ‘20+’, ‘21/30’	393
	‘26+’	431
	‘30+’, ‘31/40’	547
	‘41/50’	630
Soft and broken (S&B)	‘S&B’, ‘B&D’, ‘MIX’, ‘REJ’, ‘SMS’, ‘ERR’, *(blank)*	-

2.3. Trawl footprint

To estimate the trawl footprint of the SGPF, we obtained high-resolution vessel position data accounting for ~47% of the total trawl effort over 23 years (2001/02–2023/24). The footprint is defined as the area of seabed trawled at a mean annual trawl intensity above a predetermined level over a specified time period. The trawl footprint estimate was based on the densities of simulated trawl lines (Noell et al. 2017). Using the pixelate function in the ‘spatstat’ package in R, the aggregated trawl lines with each successive year were gridded at a resolution of 30 × 30 m. This output resolution was chosen as it is comparable to the combined trawl width[2] (29.92 m) used across the fleet, and coarser resolutions result in markedly overestimated trawled area and, consequently, underestimated untrawled area (Figure 2.1; Amoroso et al. 2018).

[2] In this study, trawl width is the total distance between both pairs of otter boards (of a double-rig configuration) at the leading edges. It is variable, and depends on sweep length, board dimensions, vessel speed and angle of attack (G. Palmer, pers. comm.).

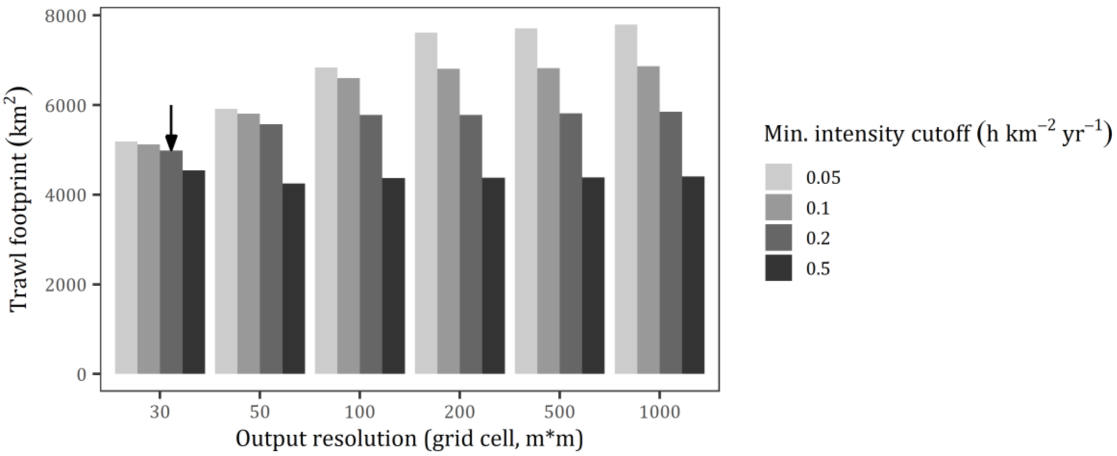

Figure 2.1. Effect of output resolution and minimum intensity cutoff (i.e., for low intensity trawling) on the total trawl footprint estimate of the SGPF over 23 years (2001/02–2023/24). The arrow indicates the settings used in the current assessment.

Each grid cell was assigned a density value *d*, which equalled the sum of trawl line lengths within the cell (m cell^{-1}), and related to trawl intensity *i* (h km^{-2}), according to the formula:

$$d = iyps\left(\frac{x}{1000}\right)^2$$

where *y* is number of years, *p* is mean coverage (proportion of total effort), *s* is mean vessel speed (m h^{-1}) and *x* is grid cell dimension (m). The tessellate function was then used to group cells by intensity category, where cutoffs were similar to those used by Currie et al. (2011). A higher minimum cutoff (i.e. 0.2 h km^{-2} yr^{-1}) was used to differentiate between ‘negligible’ and ‘low’ fishing. Using a higher minimum cut-off was considered a feasible strategy to counteract the overestimation of the trawl footprint as a result of isolated trawl paths, which are likely to be errors (Noell 2017) and were categorised as ‘negligible’. Prior to 2022/23, there were 4 intensity categories (i.e. 0–0.2 h km^{-2} yr^{-1} = ‘no/negligible fishing’, 0.2–1 h km^{-2} yr^{-1} = ‘low’, 1–10 h km^{-2} yr^{-1} = ‘moderate’, >10 h km^{-2} yr^{-1} = ‘high’). In 2022/23, an additional category was established to separate ‘no fishing’ (i.e. 0 h km^{-2} yr^{-1}) from ‘negligible fishing’ (i.e. >0–0.2 h km^{-2} yr^{-1}). The area of the trawl footprint was calculated as the sum of cells falling within the low, moderate, and high intensity categories (i.e. excluded ‘no fishing’ and ‘negligible fishing’).

Trawl footprint estimates in this assessment are based on the cumulative effect of additional trawl effort with each successive year from 2001/02–2023/24, rather than shorter timeframes, which would be considered to underrepresent the true estimate. As such, we did not consider it appropriate to compare the trawl footprint estimates of 2022/23 and 2023/24 with the composite trawl footprint for the entire 23-year period. Instead, we examined the change in the trawl footprint estimate for 2001/02–2021/22 with the addition of 2022/23 and, likewise, the change in the estimate for 2001/02–2022/23 with the addition of 2023/24.

2.4. Verification of survey data

As survey results are calculated within only a few hours after the survey, there is limited time to verify the accuracy of the electronic logbook data provided by the skippers. An extensive quality assurance process (Section 2.5) was followed to validate the survey data some months after their completion. Unvalidated and validated survey results are presented in this report and compared to determine whether there would have been any implications to the actual fishing strategy applied. Detailed maps for each survey and subsequent fishing periods throughout 2022/23 and 2023/24 are provided in Appendix A.

2.5. Quality assurance of data

2.5.1. Research planning

The research requirements for 2022/23 and 2023/24 were discussed at various times with fisheries managers and industry representatives, and subsequently presented as research scopes to confirm their understanding of proposed research and deliverables. This ensured that the proposed research was consistent with the needs of PIRSA Fisheries and Aquaculture and met the obligations in the *Fisheries Management Act 2007.*

2.5.2. Data collection

Commercial fishers were advised on the procedures and requirements for conducting surveys and completion of the required fishing logbook on a regular basis, usually at the commencement of each fishing season. The data provided by commercial fishers were checked by SARDI prior to acceptance and potential errors corrected through direct correspondence with individual commercial fishers. Independent observers were trained to record survey data using methods described in stock assessment reports for the SGPF and by following standard operating procedures in an observer handbook that is updated annually by SARDI. Each season, new industry observers are trained at an observer workshop on what information needs to be collected and the methods used to obtain the necessary prawn survey data during stock assessment and ‘spot surveys’.

2.5.3. Data entry, validation, storage, and security

All logbook data were entered and validated according to the quality assurance protocols identified for the SGPF in the SARDI Information Systems Quality Assurance and Data

Integrity Report (Vainickis 2010). Data were stored in an Oracle database, backed up daily, with access restricted to SARDI Information Systems staff. Extracts from the database were provided to SARDI prawn researchers on request. All fishery-independent data were entered into another Oracle database. Accuracy of survey data entry was verified by: (1) performing a series of checks for any inconsistencies or errors in the data file; and (2) checking a subset of the data (20%) against the original data sheets, including any errors that could not be resolved from examining the file alone. Once validated, data were uploaded and stored on a network drive with restricted access to relevant SARDI staff.

2.5.4. Data and statistical analyses

Data were extracted from the databases using established protocols. Accuracy of the data extracted was checked by comparing pivot table summaries with previous data extractions. Accuracy of data analysis was achieved by carrying out analysis for multiple years at a time (where possible) to reproduce the results of previous assessments. Analyses were completed using R statistical software (R Core Team, 2024).

3. RESULTS

3.1. Stock assessment surveys

3.1.1. Survey CPUEs

In 2022/23 and 2023/24, the mean survey $CPUE_{adults}$ was below the RP_{lower} in November and above the RP_{lower} in March and April (Figure 3.1; Table 1.8). The mean survey $CPUE_{recruits}$ has reduced from the peak in 2018/19 and 2019/20 but was above the RP_{lower} in 2022/23. In 2023/24, the mean survey $CPUE_{recruits}$ was below the RP_{lower} in November (Figure 3.1a) and April (Figure 3.1c) and above the RP_{lower} in March (Figure 3.1b). The November 2023 and April 2024 mean survey $CPUE_{recruits}$ were the lowest on record since 2004/05, and March 2024 was the fourth lowest on record (Figure 3.1). Of the three annual surveys since 2004/05, February/March and April surveys have yielded higher mean $CPUE_{recruits}$, except for 2011/12, 2020/21 and 2022/23.

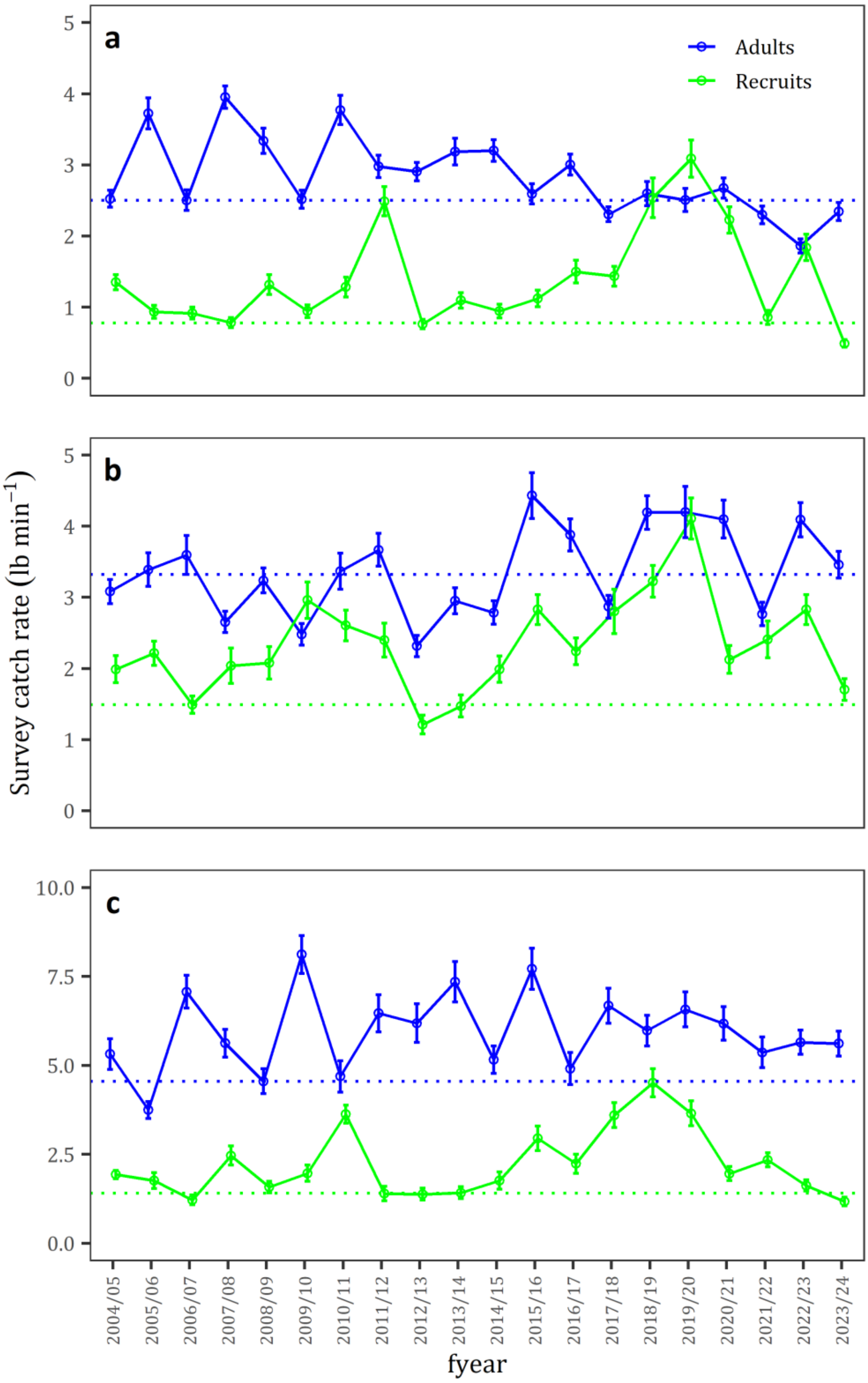

Figure 3.1. Survey mean $CPUE_{adults}$ and $CPUE_{recruits}$ (± 1 SE) during (a) October/November, (b) February/March and (c) April surveys, for 2004/05–2023/24 fishing years (fyear; 12-month period from 1 October to 30 September the following year). Blue and green dotted lines indicate the lower reference point for $CPUE_{adults}$ and $CPUE_{recruits}$, respectively, which are only used when the fishery is classified as depleting/recovering or depleted.

3.1.2. Survey bycatch

The abundance and biomass of the twenty bycatch species of interest in 2022/23 and 2023/24 by survey and location is presented in Appendix B. In 2025, an error was identified in the calculation of relative abundance and biomass (Appendix C), and corrected results are presented within this stock assessment. Across the six surveys, Blue Swimmer Crab made up the largest proportion of the bycatch weights among the non-TEP species in all surveys (overall mean 4,039 ± 313 g ha^{-1};Table 3.1, Fig. B1). Skipjack Trevally (overall mean 1,651 ± 304 g ha^{-1}) and Rough Leatherjacket (overall mean 774 ± 188 g ha^{-1}) were the next highest ranked species for biomass. Of the other managed species that are discarded, the biomass, relative to the highest ranked species, was comparatively low for King George Whiting (overall mean 37 ± 7 g ha^{-1}), Snapper (36 ± 17 g ha^{-1}) and Southern Garfish (0.5 ± 0.2 g ha^{-1}).

The number of Syngnathids caught ranged from 10 during the March 2024 survey to 63 during the October 2022 survey (Table 3.2). Among the eight known species during 2022/23 and 2023/24, the Tiger Pipefish (n = 41) and Spotted Pipefish (n = 42) were the most prevalent, which differs from the 2020/21 and 2021/22 surveys (14 Bigbelly Seahorse and 11 Spotted Pipefish). The maximum number of Syngnathids encountered at a survey location increased from 7 (Spotted Pipefish, October 2021) to 16 (Tiger Pipefish, November 2023).

Table 3.1. Overall mean biomass of the non-TEPS bycatch species sampled by the SGPF and their rank, by weight in biomass, for each of the October/November and February/March surveys in 2022/23 and 2023/24. A higher ranked species (e.g. 1) reflects a higher level of biomass compared to other species. Figures listed in parentheses are in the Appendix.

Year		2022	2023		2024
Species	**Mean biomass ($g\ ha^{-1}$)**	**Oct**	**Mar**	**Oct**	**Mar**
Blue Swimmer Crab (B1)	4039 ± 313	1	1	1	1
Skipjack Trevally (B2)	1651 ± 304	2	2	2	2
Rough Leatherjacket (B3)	774 ± 188	6	8	3	3
Port Jackson Shark (B4)	570 ± 69	3	4	4	5
Toothbrush Leatherjacket (B8)	388 ± 200	8	3	8	6
Bluefin Leatherjacket (B5)	335 ± 82	7	7	7	4
Bluespotted Goatfish (B7)	312 ± 30	4	6	5	8
Southern Calamari (B6)	299 ± 16	5	5	6	7
Eastern Balmain Bug (B9)	48 ± 4	9	11	9	11
King George Whiting (B10)	37 ± 7	10	10	10	10
Snapper (B11)	36 ± 17	11	9	11	9
Southern Garfish (B12)	0.5 ± 0.2	12	12	12	12

Table 3.2. Counts of each Syngnathid species recorded in bycatch surveys from October 2020 to March 2024 by fishing year (12-month period from 1 October to 30 September the following year).

	2020/21		2021/22		2022/23		2023/24	
Species	**Oct-20**	**Mar-21**	**Oct-21**	**Mar-22**	**Oct-22**	**Mar-23**	**Nov-23**	**Mar-24**
Tiger Pipefish	5		1	1	12	3	24	2
Rhino Pipefish	5				1			
Brushtail Pipefish			2	1	6	14		
Leafy Seadragon			1		2			8
Common Seadragon		2			4	5	7	
Spotted Pipefish			11		26		16	
Knifesnout Pipefish	1		1			1		
Bigbelly Seahorse	7	1	5	1	11	6	12	
Other Syngnathids	7			4	1			
Total	**25**	**3**	**21**	**7**	**63**	**29**	**59**	**10**

3.2. Commercial catch and effort statistics

3.2.1. Annual trends

The total prawn harvest of 1,578 t in 2022/23 and 1,465 t in 2023/24 is within the historical range of annual harvests and at the 45th and 49th percentiles recorded, respectively, since 1973/74 (mean ± SD: 1,890 t ± 302 t; CV 16%) (Figure 3.2. a).

Annual total effort over the history of the fishery can be characterised by three distinct periods (piecewise regression, R^2 = 0.95): (1) an increase from 6,795 h in 1968 to 45,786 h in 1978/79 (Figure 3.2. b), (2) a decline by 980 h per year until 2000/01 (22,089 h), and (3) a lower rate of decline (97 h per year) from 2001/02 (19,852 h) until 2023/24 (17,889 h). The mean (and SD) for the third period was 18,315 ± 1,584 h (CV 9%), which is 40% of the historic peak in 1978/79 (Figure 3.2. b). In 2022/23, total effort of 17,304 h (Figure 3.2. b) was 6% below the stable-effort mean and distributed over 48 nights and 1,848 vessel-nights. The total effort for 2023/24 of 17,889 h was also lower than the stable-effort mean (by 2%) and distributed over 50 nights and 1,904 vessel-nights. Effort was the twelfth lowest on record in 2023/24.

Annual commercial CPUE has varied greatly over the fishery's history, but there appears to be three trends, with the later trend becoming apparent with the addition of catch rates from 2022/23 and 2023/24 (piecewise regression, R^2 = 0.77): (1) commercial CPUE fluctuating around a mean (and SD) of 51.6 ± 10.2 kg h^{-1} (CV 20%) from 1968 to 1986/87, (2) thereafter increasing at a mean rate of 3.1 kg h^{-1} per year until 2007/08, and (3) increased fluctuation but an overall decrease at a mean rate of 1.1 kg h^{-1} (Figure 3.2. c). Commercial CPUE averaged 91.2 kg h^{-1} in 2022/23 and decreased slightly to 81.9 kg h^{-1} in 2023/24 (Figure 3.2. c).

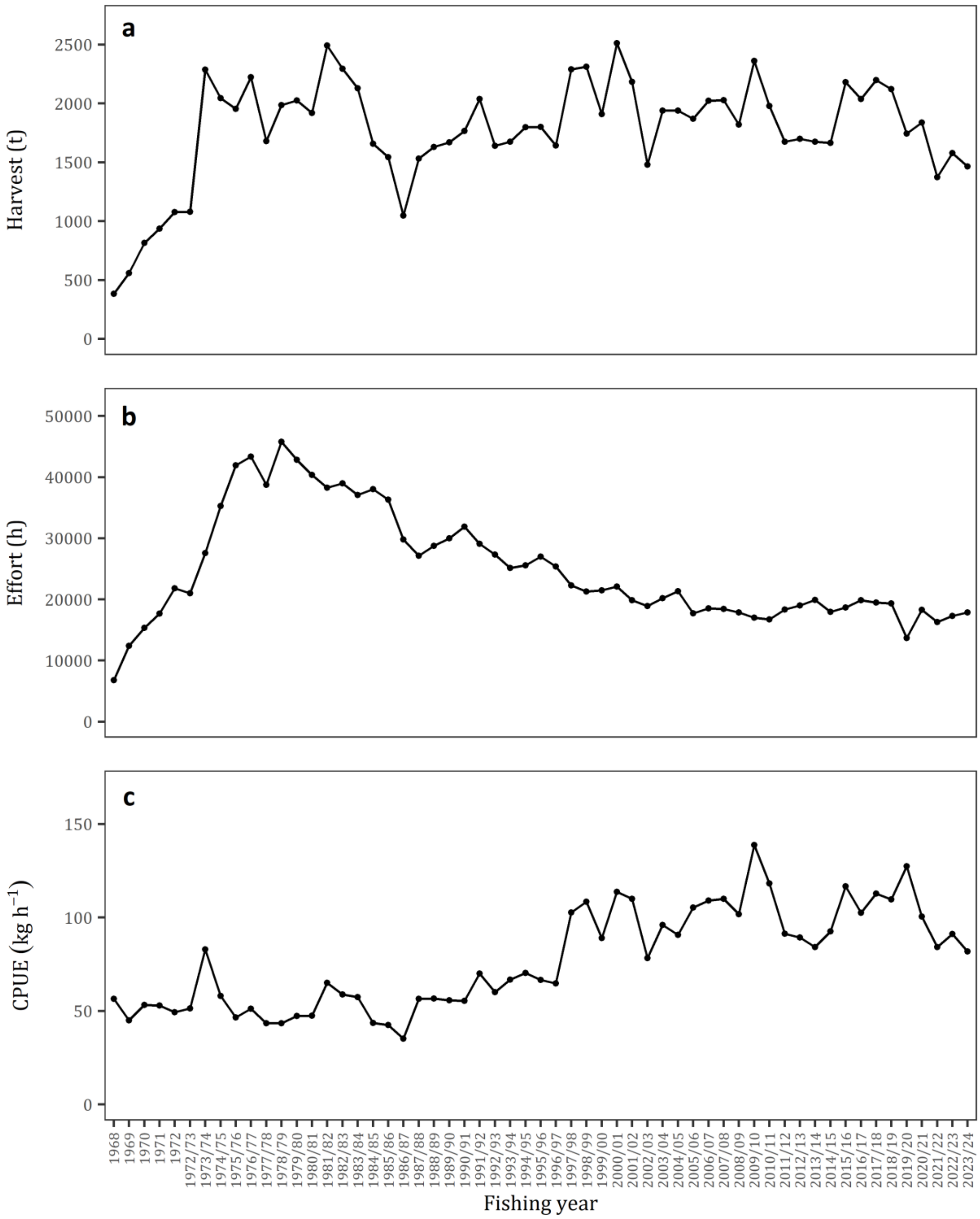

Figure 3.2. Annual (a) harvest, (b) effort, and (c) CPUE, 1968–2023/24.

3.2.2. Seasonal trends

Between 1981/82 and 1986/87, annual harvests declined from the record high of 2,491 t to the record low of 1,048 t (Figure 3.3.). During this period of decline, there were consecutive increases in the pre-Christmas harvest (i.e. October to December, during the early spawning period) from 297 t in 1979/80 to 833 t in 1983/84 (Figure 3.3.). This is the only period in the history of the fishery that pre-Christmas harvests have exceeded 500 t in consecutive years (1981/82–1983/84). Since the introduction of logbooks in 1973/74, the pre-Christmas harvest has exceeded 500 t on five separate occasions (1991/92, 1995/96, 1998/99, 2001/02 and 2010/11) (Figure 3.3.). Each time, a decline in annual harvest was observed in the following year. The pre-Christmas harvest was 242 t in 2022/23 and 390 t in 2023/24 (Figure 3.3.), which represent 15% and 27% of respective total harvests in those seasons (cf. historic mean of 23% since 1973/74).

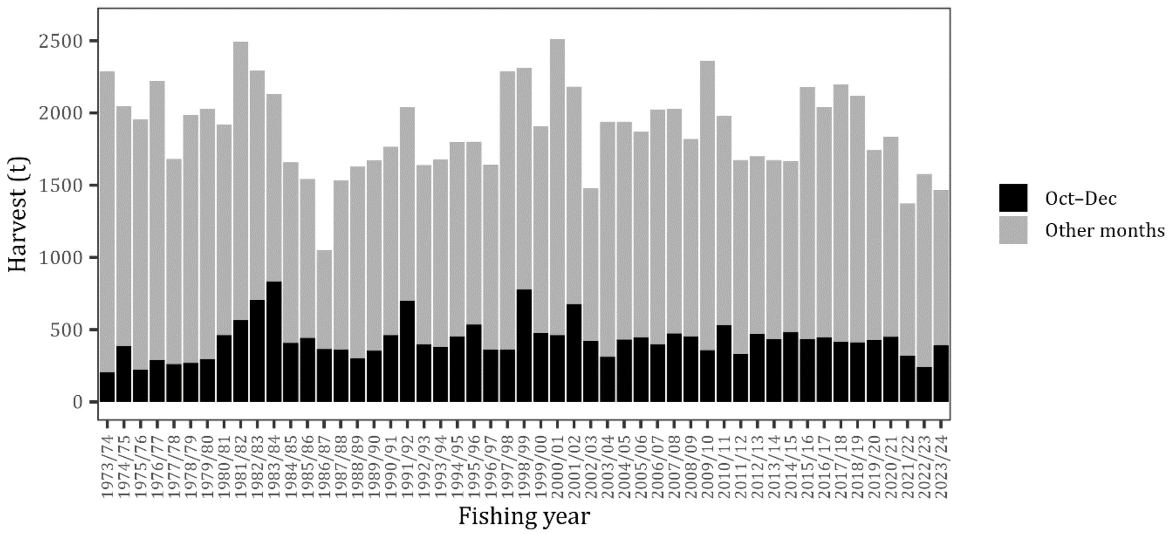

Figure 3.3. Annual harvest separated into the pre-Christmas period (October–December) and other months of the fishing year, 1973/74–2023/24.

Based on the catch and effort data recorded since 1990/91, most of the annual harvest is taken over six months, in November and December, and March to June, with greatest harvests in April and May (Figure 3.4. a). The monthly distribution of total harvests in 2022/23 and 2023/24 followed this general pattern, except for increased harvest in October 2022 which, in alignment with the lunar cycle, enabled two fishing runs prior to Christmas markets (i.e. October and November) (Figure 3.4. a).

For the six main fishing months, the historic distribution of monthly mean CPUEs suggests that CPUE tends to rise and fall in unison with monthly harvests (Figure 3.4. b). Similar to the distribution of harvests, the monthly CPUEs in 2022/23 and 2024/25 followed the long-term trend, except for the October 2022 catch rate, which was lower than the historic mean (Figure 3.4. b).

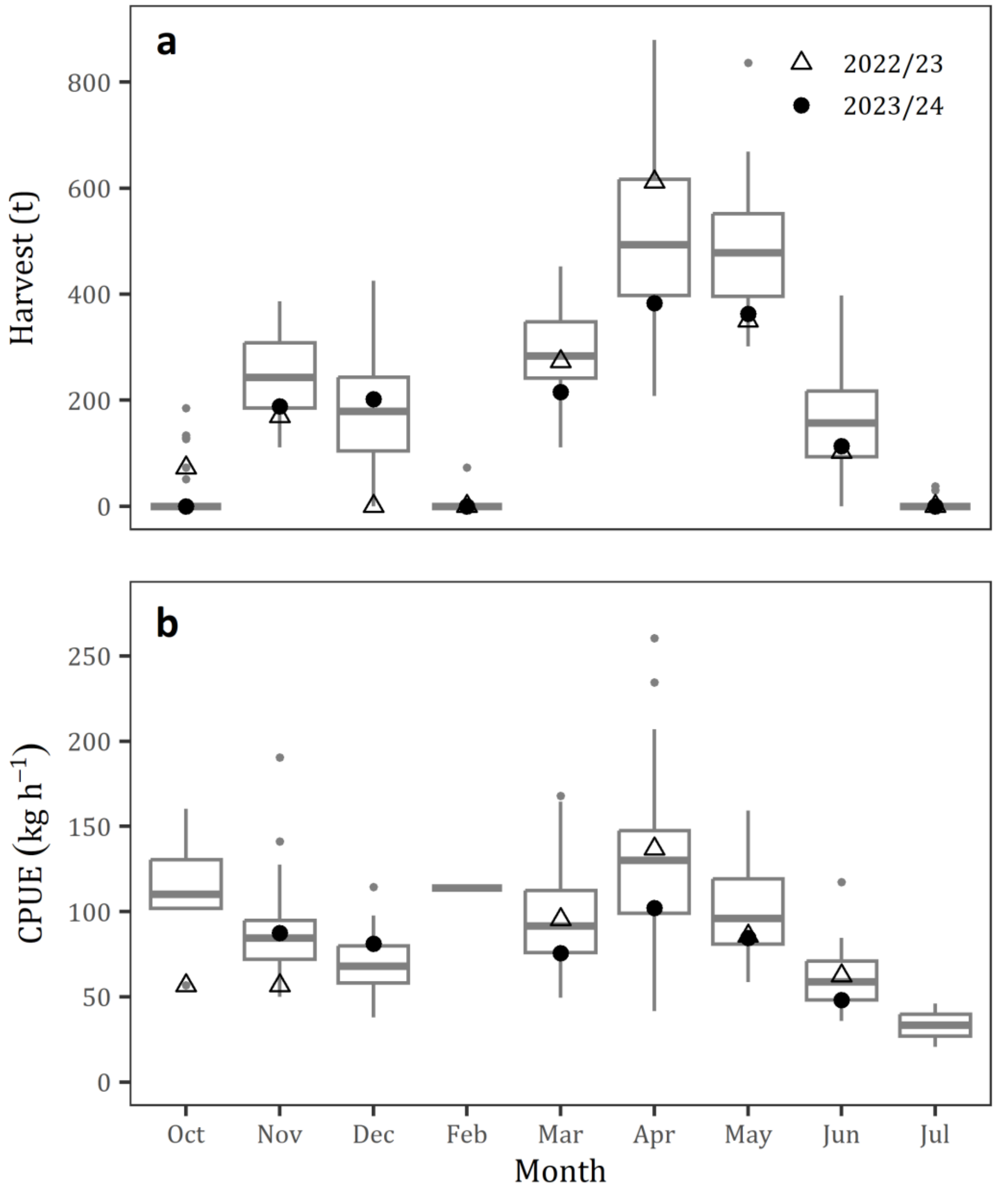

Figure 3.4. Monthly distribution of (a) annual harvest and (b) CPUE, 1990/91–2023/24. Fishing years 2022/23 and 2024/25 are highlighted. The boxplot displays the median (thick horizontal line), first and third quartiles (the interquartile range, IQR; box), the spread of values no further than 1.5 IQR beyond the IQR (whiskers), and all outliers (points).

3.2.2. *Regional trends*

Since 1990/91, harvests from the three regions in the upper gulf, including North, Middlebank/Shoalwater and Wallaroo, have 1) collectively made up 63–90% of the annual total harvest (Figure A.1), 2) an annual mean of 76%, and 3) an increasing trend from 1990/91 to 2010/11 and 2015/16 to 2022/23 (Figure 3.5). The contribution of these regions to the total harvest was the highest value on record in 2022/23 (90%) and in the upper range of historic values in 2023/24 (75%). In 2022/23, the contribution of catch was highest from Wallaroo (48%), while in 2023/24 catch contribution was slightly higher in North (30%) than Wallaroo (26%) (Figure 3.6. a).

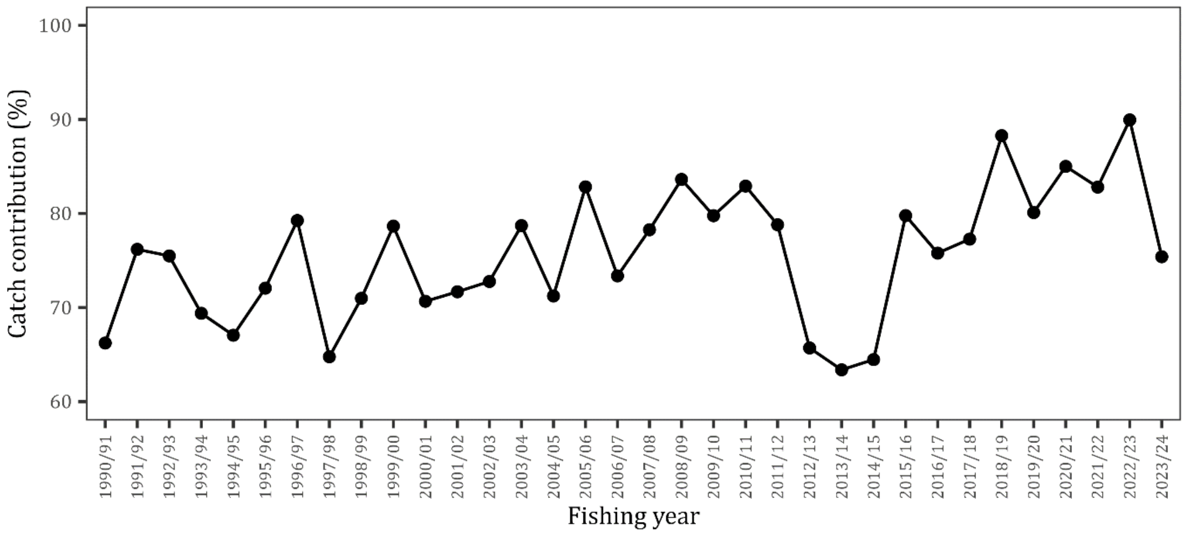

Figure 3.5. Catch contribution (%) from the upper gulf, including North, Middlebank/Shoalwater, and Wallaroo, in each year from 1990/91 to 2023/24.

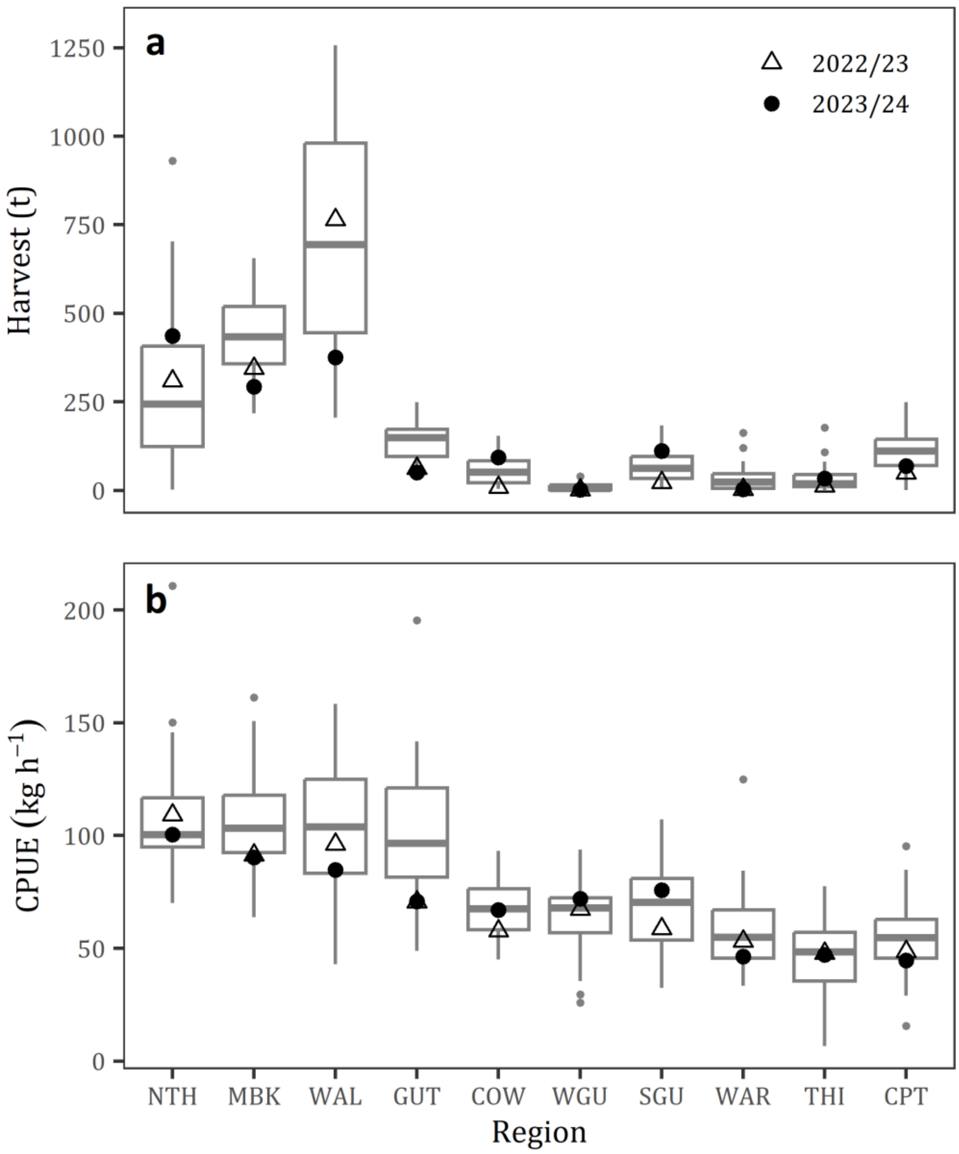

Figure 3.6. Regional distribution of (a) harvest and (b) CPUE, 1990/91–2023/24. Fishing years 2022/23 and 2023/24 are highlighted. See Figure 3.4. for boxplot features. See Figure 1.1 for abbreviations of regions.

Fishery CPUEs are generally higher in the same three regions—along with the Gutter—in the upper gulf than regions further south (Figure 3.6. b). This pattern was observed in 2022/23 and 2023/24, with CPUE being higher in 2022/23 than 2023/24 in the upper gulf regions (Figure 3.6. b).

3.2.4. Prawn size

In 1978/79, small prawns made up ~40% of the annual harvest. Since 2002/03, this size category has generally contributed less than 7%, but it increased to 7–9% for three of the last four years (7% in 2020/21, 9% 2021/22, and 7% in 2022/23; Figure 3.7.). In 2023/24, the percentage of small prawns in the annual harvest decreased to 5%. The overall reduction in the proportion of small prawns (since the late 1970s) has been offset by at least two-fold increases in the proportions of large (from 21% to 39–51%) and extra-large prawns (from 6% to 13–24%) (Figure 3.7.). The proportion of large prawns in 2022/23 (38%) and 2023/24 (41%) was at the lower end of its range (Figure 3.7.). The proportion of soft and broken prawns throughout this period has consistently ranged between 5% and 8%.

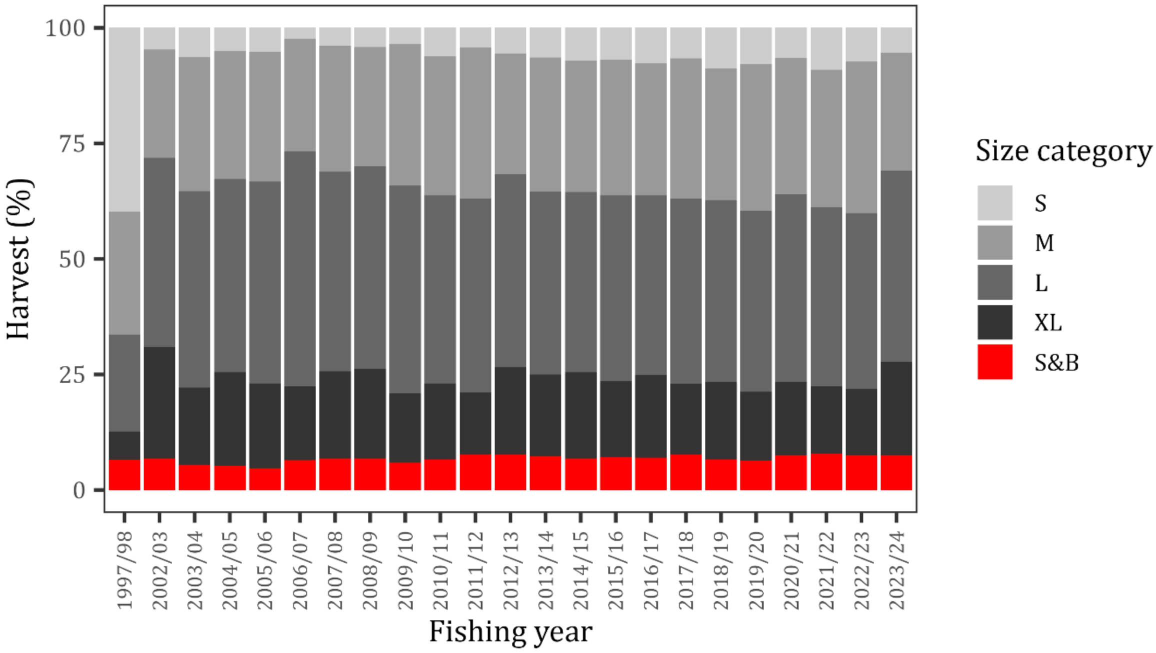

Figure 3.7. Size composition of annual harvest, 1997/98 and 2002/03–2023/24. Abbreviations: S, small; M, medium; L, large; XL, extra-large; S&B, soft and broken.

Annual mean bucket counts of 227 and 212 prawns per 7-kg bucket were recorded in 2022/23 and 2023/24, respectively. The 2023/24 bucket count was the fifth lowest bucket count on record, which is a significant increase in larger prawn sizes, compared to 2021/22 which had the highest bucket count (or the smallest prawn sizes) since 2002/03. On average, since 2012/13, there has been a gradual trend of reducing prawn size except for the temporary increase in 2020/21 and 2022/23–2023/24 (Figure 3.8.).

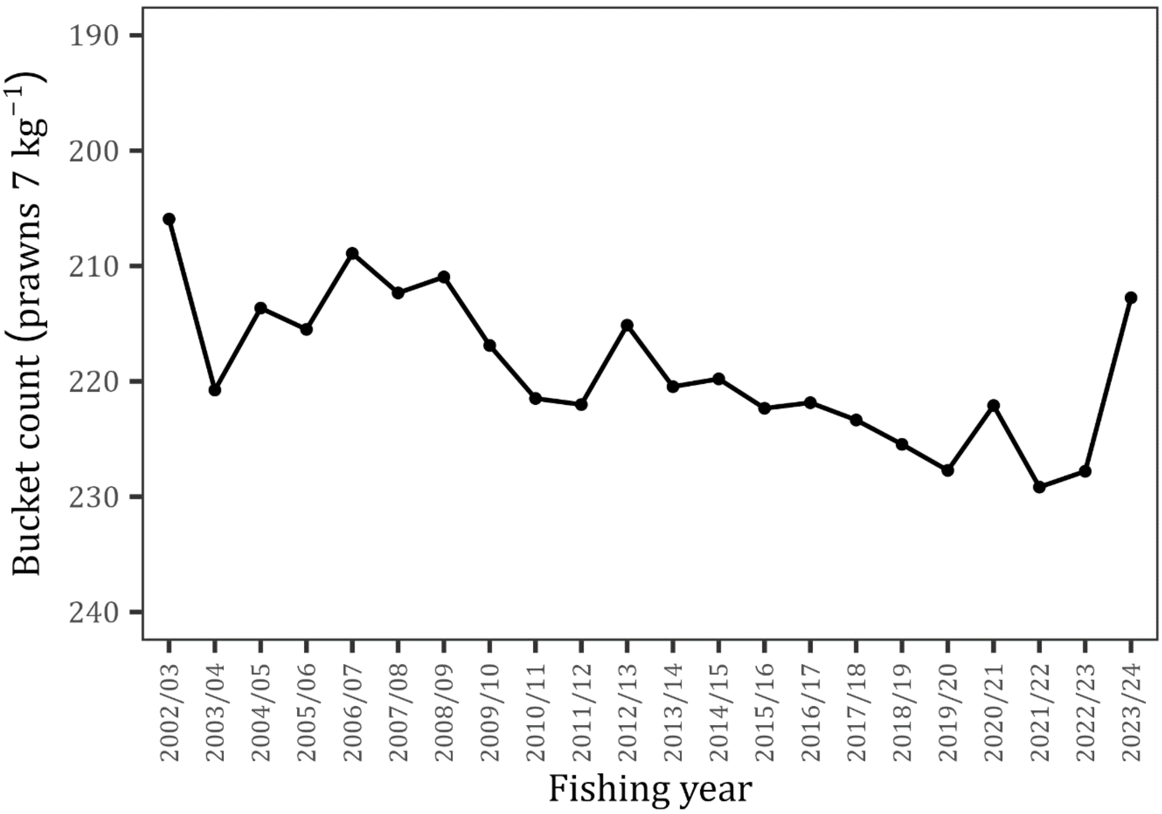

Figure 3.8. Estimated annual mean bucket count, 2002/03–2023/24. Note: the y-axis scale is reversed to denote decreasing (increasing) prawn size with higher (lower) bucket counts.

3.3. Trawl footprint

Based on available GPS coordinates of trawl midpoints over the 23-year period since 2001/02 (representing approximately 47% of total effort), the trawl footprint (i.e. the sum of cells falling within the low, moderate, and high intensity categories) of the SGPF is estimated to be 5,080 km^2 (Figures 3.9. and 3.10). This represents approximately 22% of the entire Gulf area. Within the footprint, 486 km^2 (10%) was trawled at high intensity (>10 h km^{-2} yr^{-1}), 2,810 km^2 (55%) at moderate intensity (1–10 h km^{-2} yr^{-1}), and 1,785 km^2 (35%) at low intensity (0.2–1 h km^{-2} yr^{-1}) (Figure 3.10.). The total footprint estimates generally plateaued, with the annual rate of expansion reducing in successive years from 3.9% in 2016/17 to 0.6% in 2019/20. The annual rate of expansion from 2020/21 to 2023/24 was variable but generally decreased to 0.5% in 2022/23 before increasing to 1.4% in 2023/24 (Figure 3.10.). The composition of the footprint over the last five years (since 2019/20) demonstrates that the greatest absolute change occurred for the low intensity category, with a net increase of 123 km^2 (compared to a net increase of 53 km^2 and 16 km^2 for the moderate and high intensity categories, respectively)

(Figure 3.10.). The negligible category, which is not included in the total trawl footprint, would increase the total trawled area by 5.7% (to 5,370 km^2) and had a net absolute increase of 47 km^2 over the last five years.

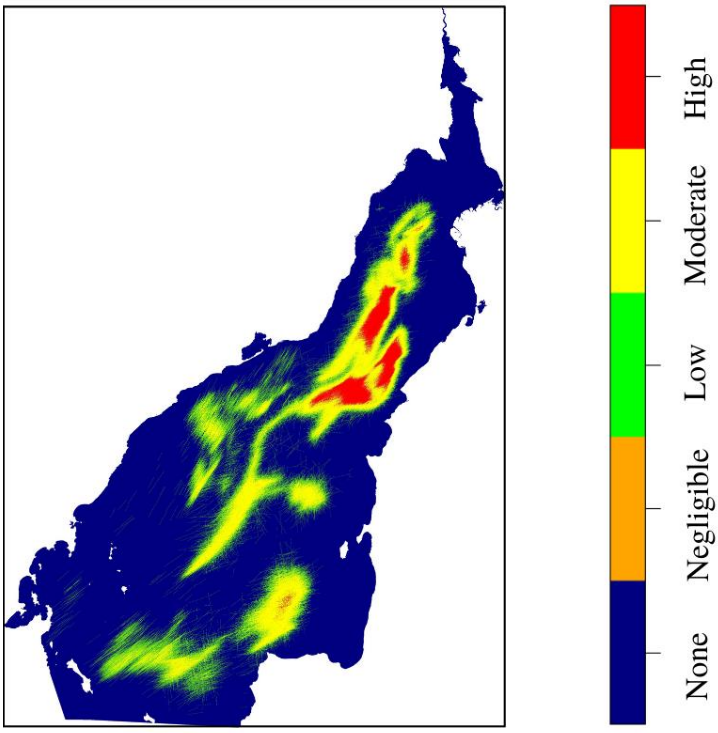

Figure 3.9. Trawl footprint of the SGPF (based on ~47% of the total effort, 2001/02–2023/24), and the high (>10 h km^{-2} yr^{-1}), moderate (1–10 h km^{-2} yr^{-1}), and low (0.2–1 h km^{-2} yr^{-1}) and negligible (0< x ≤0.2 h km^{-2} yr^{-1}) trawl intensity areas within the footprint.

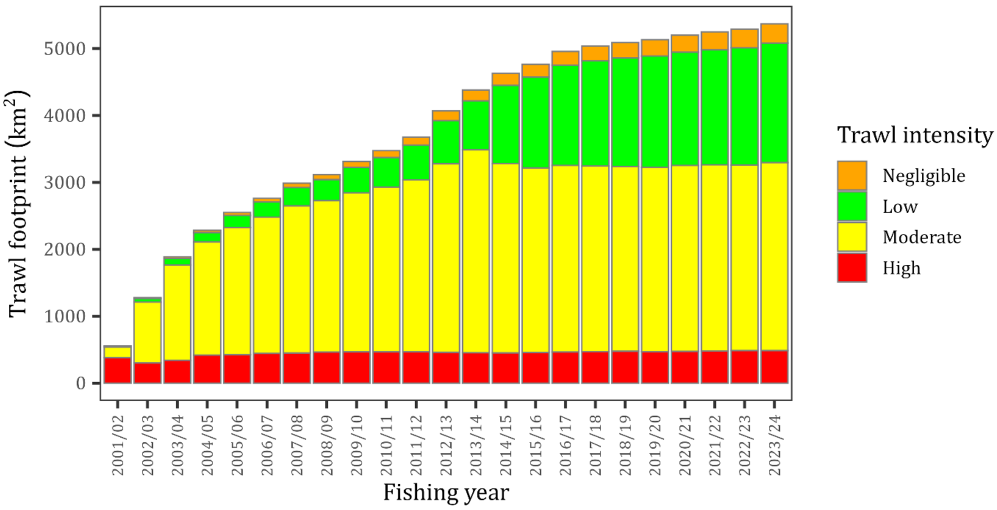

Figure 3.10. Cumulative effect on the trawl footprint of the SGPF with each successive year, 2001/02–2023/24, and proportion of trawl intensity category within the footprint. See Figure 3.9. for definition of trawl intensity categories.

3.4. Fishing strategy assessment

At the end of fishing years 2022/23 and 2023/24, a series of checks were performed on the survey data to verify their accuracy and resolve any errors. This process indicated that, before validation, there was a tendency for $CPUE_{adults}$ to be overestimated by up to 4% and $CPUE_{recruits}$ to be over/underestimated by up to 4% (Table 3.3).

Table 3.3. Summary of reference points and mean survey $CPUE_{adults}$ and $CPUE_{recruits}$ (unvalidated and validated) for the 2022/23 and 2023/24 stock assessment surveys, and subsequent fishing strategy and decision rules prescribed for in the management Plan. Where two criteria are given for bucket count or mean nightly catch, the first refers to the northern part of the gulf and the second refers to the southern part of the gulf.

Survey	$CPUE_{adults}$ (lb min^{-1})			$CPUE_{recruits}$ (lb min^{-1})			Fleet catch cap (t)	7-kg bucket count	Nightly catch (kg)
	RP_{lower}	Unvalid.	Valid.	RP_{lower}	Unvalid.	Valid.			
2022/23									
November	2.50	1.94	1.86	0.78	1.85	1.84	350 t	≤260	-
March	3.32	4.16	4.09	1.49	2.72	2.83	-	≤240/260	≥500/350
April	4.55	5.70	5.65	1.41	1.60	1.62	-	≤260	≥500/350
2023/24									
November	2.50	2.37	2.34	0.78	0.49	0.49	400 t	≤260	-
March	3.32	3.46	3.46	1.49	1.70	1.70	-	≤240/260	≥500/350
April	4.55	5.57	5.61	1.41	1.21	1.17	-	≤260	≥500/350

3.5. Fishery performance

The primary PI of weighted mean survey $CPUE_{adults}$ (±95% CI) was 4.35 ± 0.34 lb min^{-1} and 4.20 ± 0.34 lb min^{-1} for 2022/23 and 2023/24, respectively (Figure 3.11.). In 2022/23 and 2023/24, the primary PI was above the LRP (2.21 lb min^{-1}) and TRP (3.16 lb min^{-1}). The secondary indicator, the weighted mean survey $CPUE_{recruits}$ (±95% CI), was within the 'medium' reference level (≥ 1.09 < 2.18 lb min^{1} in 2022/23 (2.09 ± 0.21 lb min^{1} and 2023/24 (1.22 ± 0.15 lb min^{-1}) but does not influence decisions within the parameters of the harvest strategy framework.

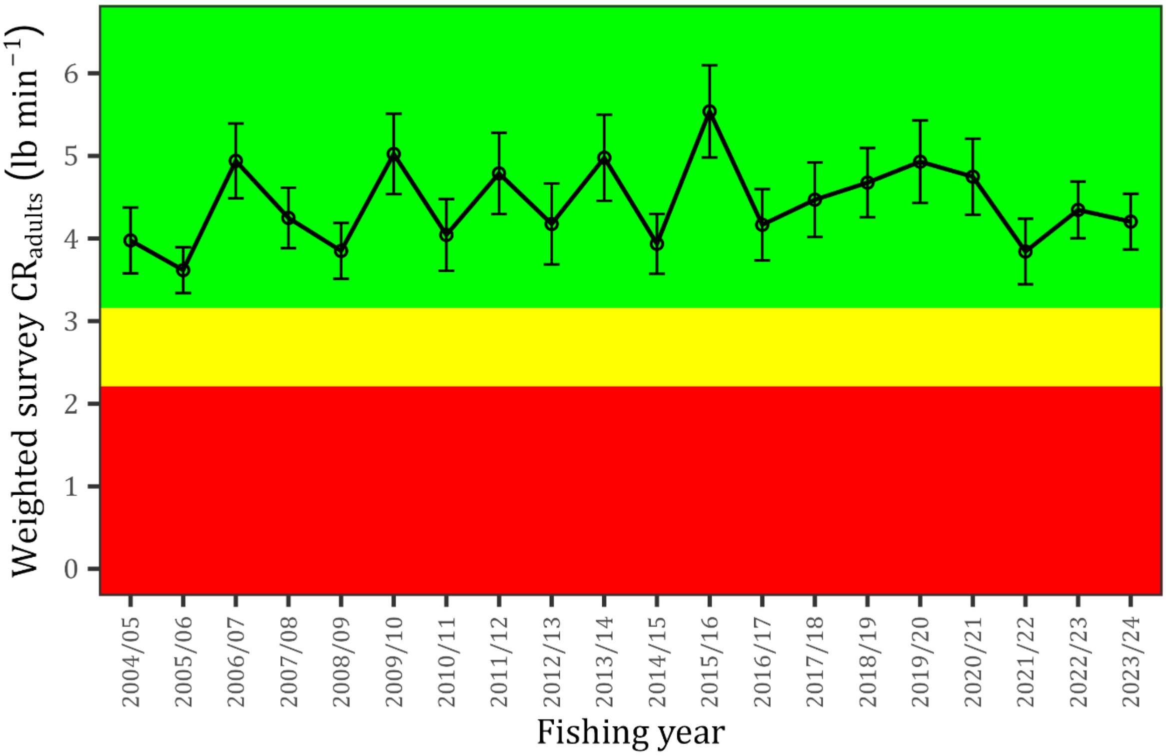

Figure 3.11. Weighted mean survey CPUE$_{adults}$ (± 95% CI), 2004/05–2023/24, and corresponding stock status classification (green shading indicates a sustainable stock, yellow indicates a depleting/recovering stock, and red indicates a depleted stock).

4. DISCUSSION

4.1. Main information sources for the fishery

Extensive information was available to assess the Western King Prawn stock and general performance of the SGPF for 2022/23 and 2023/24. This included: (i) management arrangements of the fishery (PIRSA 2020); (ii) two decades of an annual/biennial stock assessment program (Carrick 2003; Dixon et al. 2005, 2007; Dixon and Hooper 2008; Dixon et al. 2009, 2010, 2012, 2013; Noell et al. 2014; Noell and Hooper 2015, 2017, 2019, 2021; Heldt and Hooper 2023); (iii) a comprehensive biological synopsis of the Western King Prawn (Noell et al. 2015); (iii) prawn size and catch rate data obtained from three annual stock assessment surveys; (iv) by-product and bycatch information obtained during two of the three annual stock assessment surveys; and (v) commercial catch, effort and prawn size data.

4.1.1. Stock assessment surveys

All three annual stock assessment surveys were completed during 2022/23 and 2023/24, with fishing strategies developed immediately afterwards in accordance with a sustainable stock (as described in Advice Notes to PIRSA Fisheries and Aquaculture in October 2023 and 2024). In 2022/23 and 2023/24, mean survey $CPUE_{adults}$ remained above their respective RP_{lower} except for November 2022 and 2023, and $CPUE_{recruits}$ remained above their respective RP_{lower} except for November 2023 and April 2024. The lower RPs are not used in the conventional sense for determining stock status, but rather were designed to maintain the relative biomass within historic levels and are assumed to be well above a level at which overfishing is likely to have occurred. In 2023/24, $CPUE_{recruits}$ were some of the lowest on record; this decrease was considered during the development of fishing strategies immediately after stock assessment surveys, which is one of the features that have placed the SGPF as a leader in co-management.

The stock assessment surveys also provide key abundance and biomass information twice per year for a limited number of key bycatch and by-product species considered important with respect to the MSC criteria. However, it is important to note that (1) under the current survey design, the impact of the SGPF on bycatch species cannot be quantified and the cause(s) of any fluctuations in relative abundance and biomass cannot be determined from these estimates alone, (2) developing spatial and temporal analyses for available bycatch data (5 years of data) may be beneficial for establishing long-term trends, and (3) it has been >10 years since the last gulf-wide survey (Burnell et al. 2015).

Additionally, Noell (2022) first presented apparent differences in reporting of Syngnathid species between surveys and fishing, with some underreporting occurring during commercial fishing. The differences observed from 2022/23 to 2023/24 were reduced relative to previous surveys. In future, it will be important to continue a combination of ongoing survey monitoring, education awareness on TEPS reporting requirements, and additional spatial and temporal comparison of reporting rates. Importantly, estimates from the surveys should be provided within the context of the fishery's initiatives, aim to meet the MSC criteria v3.1 (MSC, 2024), and continue to incorporate monitoring of TEPS species.

It should also be recognised that, in their last two assessments by the MSC, the SGPF has not had any conditions in relation to 'principle two' species components. This is largely a consequence of continued and successful initiatives by the fishery over the years to: (1) avoid incidental capture of non-target species (through substantial reductions in effort and trawl footprint, and permanent/voluntary closures); (2) develop and trial various bycatch reduction devices (Nordmøre-grid, 'fisheye', submerged LED light; Kennelly and Broadhurst 2014; Noell et al. 2018), with some devices being adopted; and (3) develop onboard handling practices that minimise mortality of discarded bycatch ('crab bags', separation racks, hopper system and conveyor belts). A key focus in SGPF is understanding the impact of Light Emitting Diodes (LEDs) on prawn catch and finfish bycatch as part of an FRDC project (2023-039) – "Assessing the effectiveness of LEDs, T90 cod-end/grid trawl systems and net modifications for reducing bycatch and improving efficiency and selectivity of catches in South Australian prawn fisheries". While species specific information is not available for all initiatives in the SGPF, it is reasonable to assume that each initiative would have reduced impacts (to varying degrees) to a portion of non-target species.

4.1.2. Commercial logbook data

Unlike stock assessment survey results for this fishery, which are independent and provide an index of biomass for the Western King Prawn, annual harvests are considered to be more of an economic indicator and are not a performance indicator in the Management Plan. The total prawn harvest of 1,578 t in 2022/23 and 1,465 t in 2023/24 is within the historical range of annual harvests and at the 45th and 49th percentiles recorded, respectively, since 1973/74 (mean ± SD: 1,890 t ± 302 t; CV 16%). Annual commercial CPUE in recent years showed increased fluctuation, but an overall decrease (mean rate of 1.1 kg h^{-1}) since 2008/09. Effort during this period was relatively stable, with reduced catches primarily driving the declining trend in CPUE.

The breakdown of the annual harvest by size category and the mean bucket count indicates that the average size of prawn over the last several years has generally decreased, with 2020/21 and 2022/23–2023/24 as exceptions. The new harvest strategy provides greater flexibility in the areas opened to fishing by having less conservative prawn size criteria (i.e., higher bucket counts) but restricting the number of nights fished (and catch) within each region (PIRSA 2020). It is likely that this approach combined with consecutive years of high (and record) recruitment in 2018/19 and 2019/20, influenced the size composition and bucket counts recorded prior to 2020/21. In contrast, in 2023/24, the bucket count was the fifth lowest on record, which is a significant increase in larger prawn sizes, likely driven by more conservative fishing strategies in 2024 to meet the economic objectives of the fishery (i.e., prawn size criteria set at lower bucket counts). It is also worth noting that the decrease in pre-Christmas harvest in 2022/23 was also in part due to the application of more conservative fishing strategies. Further to meeting economic objectives, conservative fishing strategies also support fishery sustainability by enabling growth of small prawns and/or reducing overall fishing pressure, with both being accounted for during fishing strategy development.

Trawl footprint analyses demonstrated that, in general, there was a consistent spatial fishing pattern each year (Noell 2017). With the addition of 2022/23 and 2023/24 trawl tracks (to trawl effort data starting from 2001/02), the updated cumulative trawl footprint estimate is 5,080 km^2. By distinguishing between the intensity categories of ‘no fishing’ (i.e. 0 h km^{-2} yr^{-1}) and ‘negligible fishing’ (less than 0.2 h km^{-2} yr^{-1}), this assessment provides quantification of isolated trawl paths, which are likely to be errors (Noell 2017) and are not clearly visible on the trawl footprint map. The ‘negligible fishing’ category was excluded in the calculation of total trawl footprint area and comprises a relatively small percentage of total trawl area. Ongoing annual and cumulative estimates of the trawl footprint provide information on whether the fishery continues to largely fish the same areas or is expanding into ‘new’ areas. A key measure of determining the expansion of the trawl footprint is the annual rate of increase in the cumulative area fished. The total footprint estimates generally plateaued from 2016/17 to 2019/20, suggesting that the trawl footprint approached saturation under current management arrangements. However, the annual rate of expansion increased slightly in 2023/24 with the greatest absolute change occurring in the low intensity category. Changes to fishing strategies in 2023/24, amongst other factors, may have impacted fisher behaviour and the trawl footprint area. The rate of expansion should continue to be monitored carefully in future years, and extending the scope of this work is the FRDC project 2020/002 ‘Nature and extent of the ecological assets conserved by the Spencer Gulf Prawn Fishery to mitigate their ecological footprint’ (Grammer et al. 2025).

4.2. Stock status

A key feature of the current harvest strategy in the Management Plan is that it explicitly links a weighted mean survey $CPUE_{adults}$ from all three stock assessment surveys to an end-of-year stock status classification, which is delineated by the LRP and TRP. The weighting factors of 0.20 for October/November, 0.35 for February/March and 0.45 for April are measures of the perceived importance of each survey in reflecting the stock biomass to determine stock status at the end of the fishing year. Importance was based on their measure of relative exploitable biomass, recruitment and timing using the methodology described in the Management Plan (PIRSA 2020). Stock status terminology is also consistent with that of the national status reporting framework (Roelofs et al. 2024). The determination of an end-of-year stock status for the SGPF is important as each status classification (sustainable, depleting or recovering, and depleted) drives a specific set of fishing strategies, decision rules, and criteria that are applicable in the following year. Advanced notice of this information (i.e., before the start of the fishing year) provides PIRSA Fisheries and Aquaculture with a clear understanding of the stock status for the fishery and how it was derived and provides industry with greater certainty for planning its fishing operations for the year ahead.

Following validation of mean survey $CPUE_{adults}$ for October/November, February/March, and April surveys during 2022/23 and 2023/24, the weighted mean $CPUE_{adults}$ (± 95% CI) was 4.35 ± 0.34 lb min^{-1} and 4.20 ± 0.34 lb min^{-1} for 2022/23 and 2023/24, respectively; both of which are above the LRP of 2.21 lb min^{-1} and TRP of 3.16 lb min^{-1}. Under the definition in the harvest strategy, the stock is classified as '**sustainable**'.

4.3. Future research needs

Key areas for further research and development include:

1. Continue research investigating the effectiveness of artificial LEDs to reduce finfish bycatch without prawn loss through FRDC project 2023-039.
2. Revise and/or augment bycatch monitoring programs, as needed, to meet the requirements of MSC v3.1.
3. Identify key environmental drivers in Spencer Gulf and examine whether these environmental factors can be used inform to inform management practices in the SGPF.

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APPENDIX A. MAPPING OF SURVEY AND FISHING RESULTS

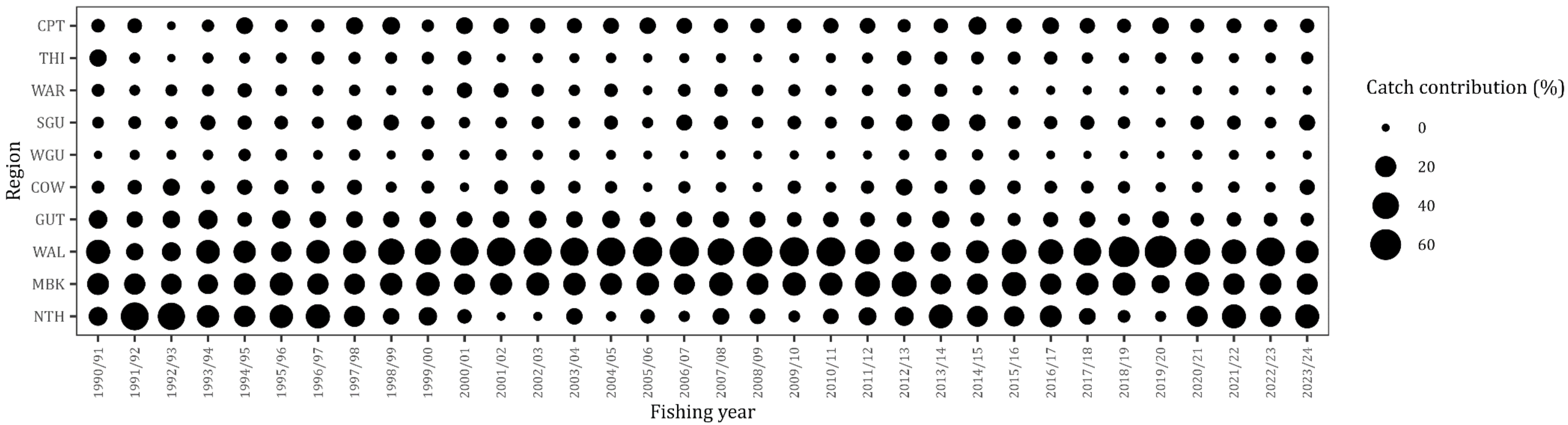
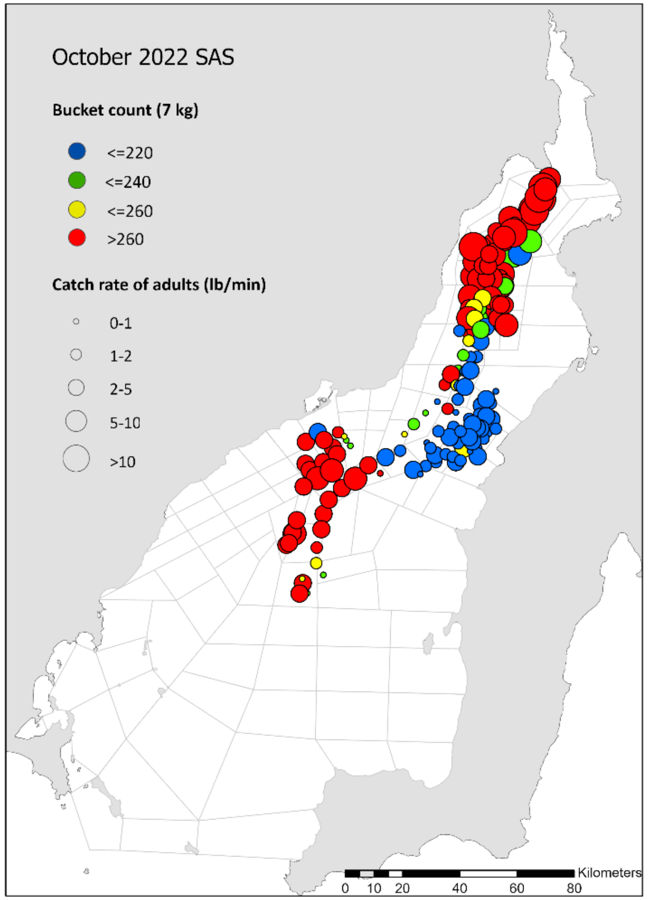


Figure A.1. Catch contribution (%) for each region and year (1990/91–2023/24). See Figure 1.1 for abbreviations of regions.

a)



b)

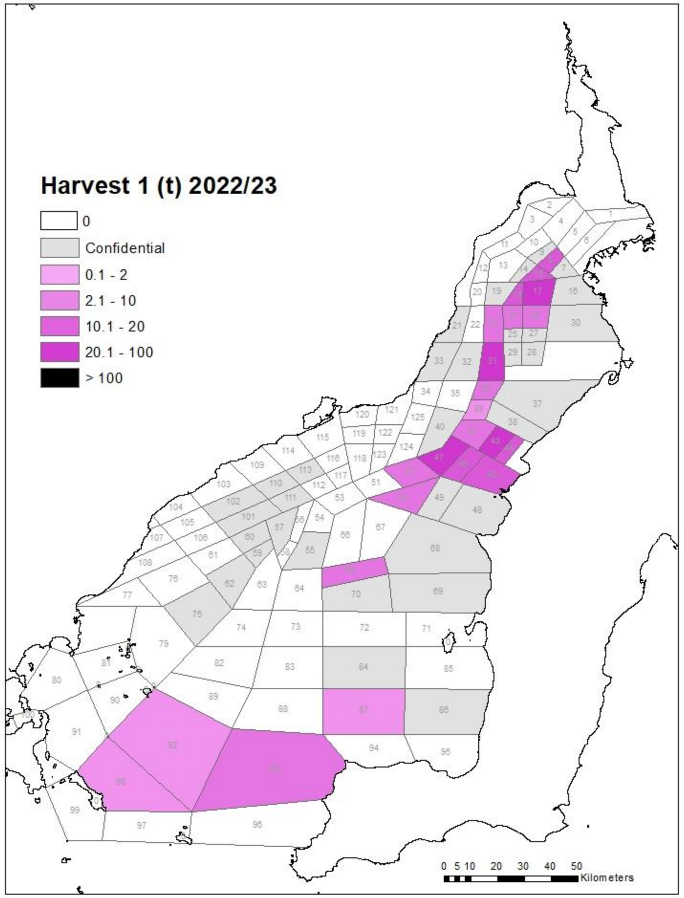


Figure A.2. (a) Results of 24–25 October 2022 survey and (b) subsequent harvest by block during the first harvest period (fishing periods 1 and 2 from 26–29 October 2022 and 21–30 November 2022, respectively).

a) b)

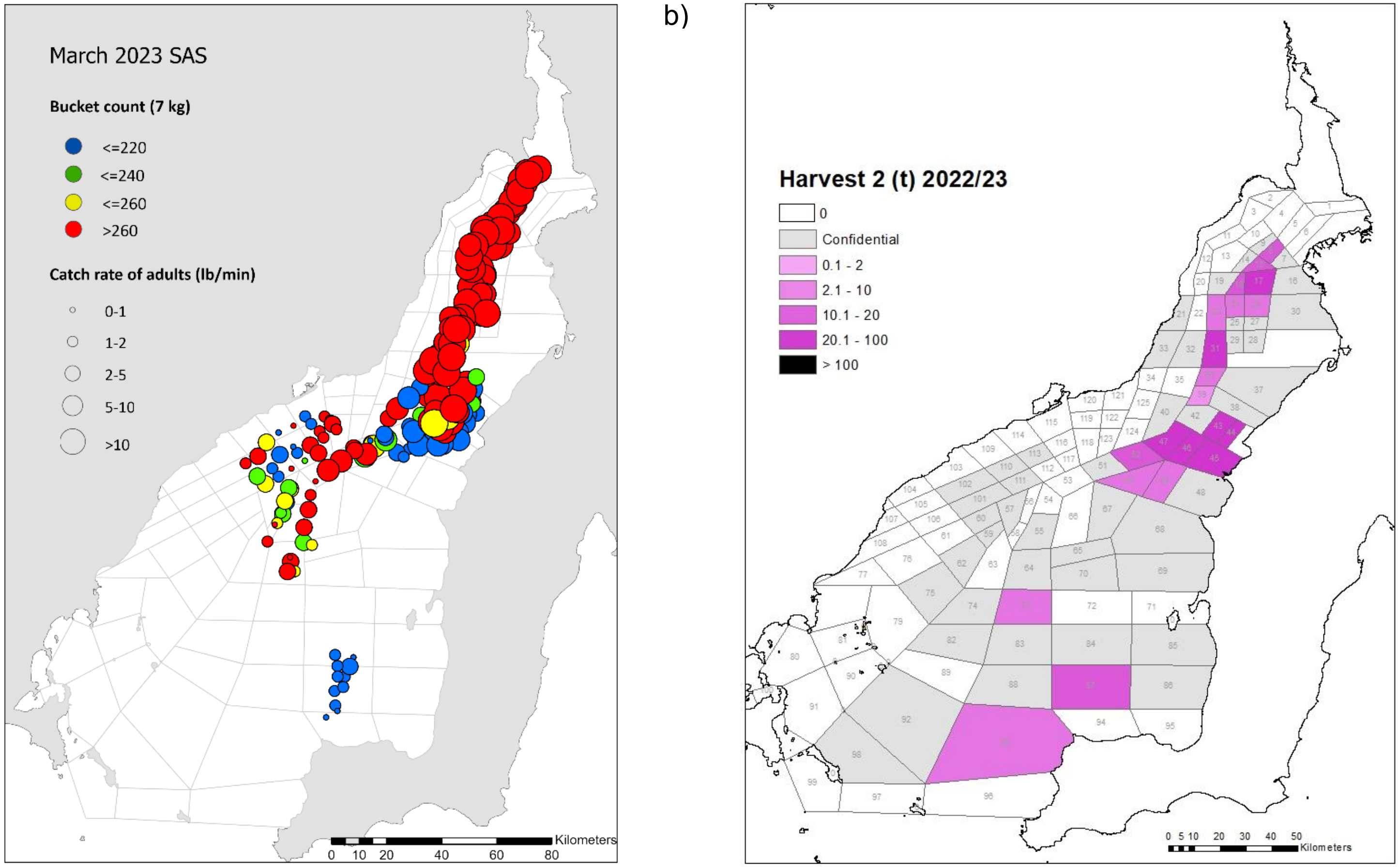


Figure A.3. (a) Results of 20–21 March 2023 survey and (b) subsequent harvest by block during the second harvest period (fishing period 3 and 4 from 22–29 March 2023 and 17–29 April 2023, respectively).

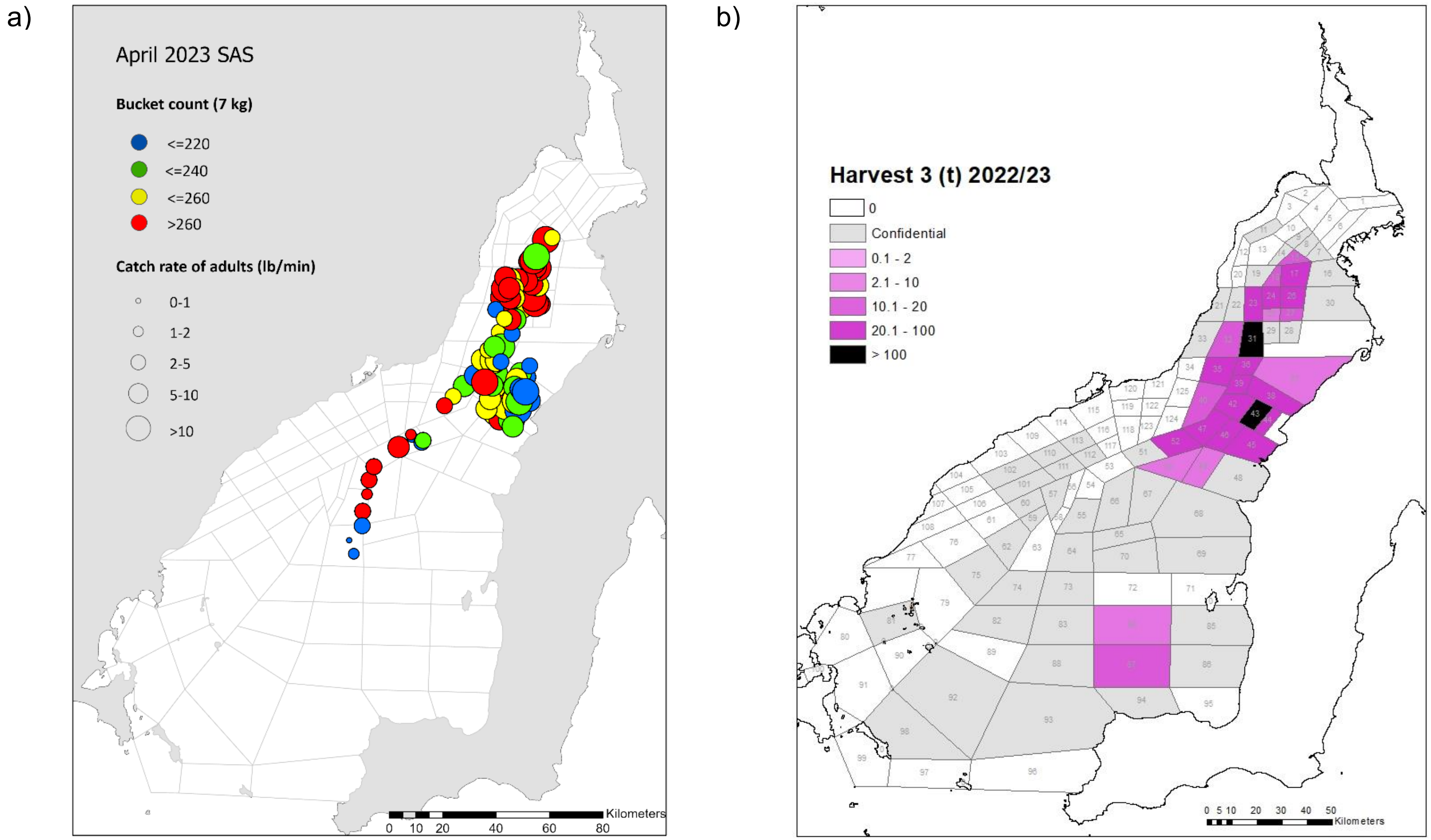
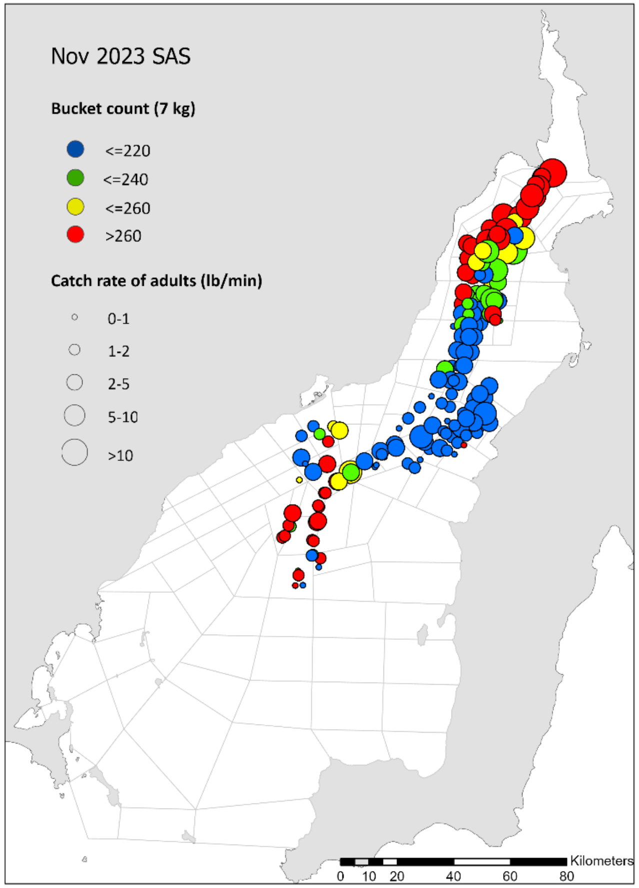


Figure A.4. (a) Results of 19 April 2023 survey and (b) subsequent harvest by block during the third harvest period (fishing period 5 and 6 from 17–28 May 2023 and 17–20 June 2023, respectively).

a)



b)

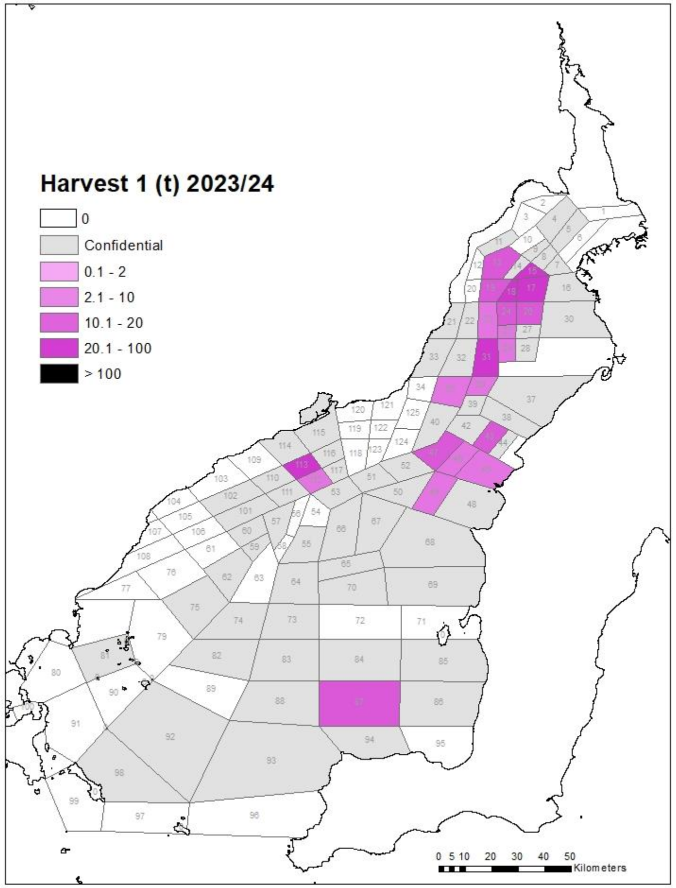
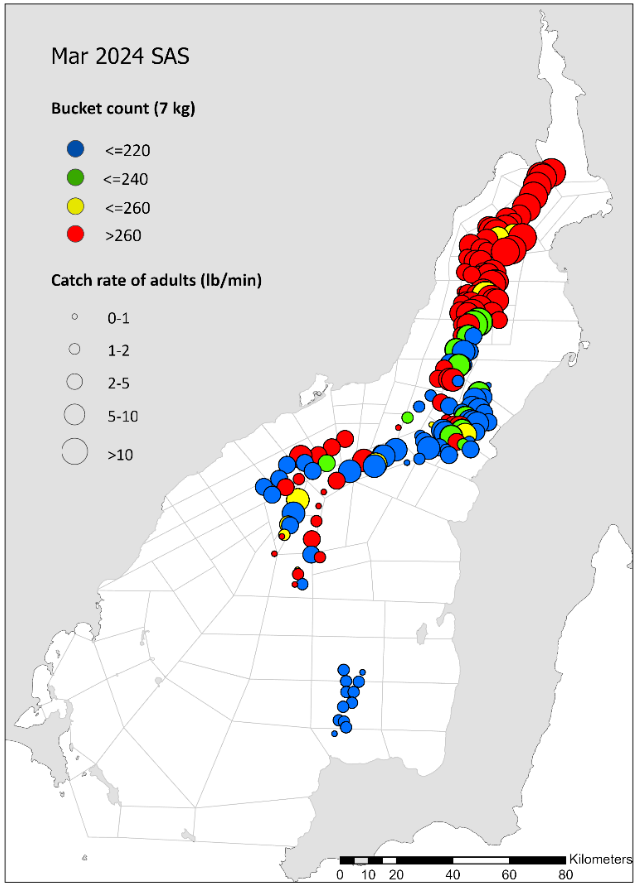


Figure A.5. (a) Results of 12–13 November 2023 survey and (b) subsequent harvest by block during the first harvest period (fishing period 1 and 2 from 14–20 November 2023 and 9–17 December 2023, respectively).

a)



b)

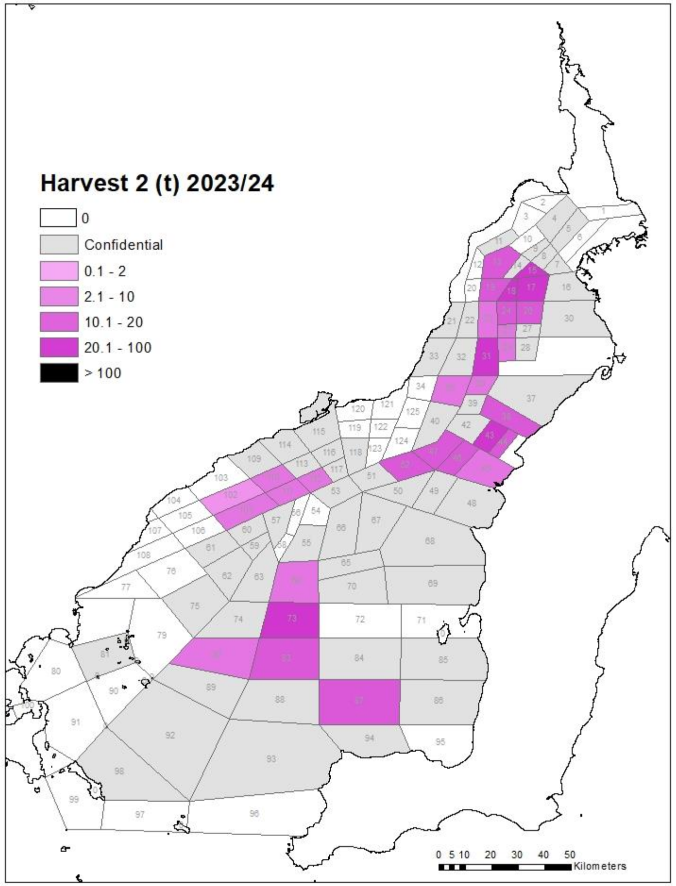


Figure A.6. (a) Results of 9–10 March 2024 survey and (b) subsequent harvest during the second harvest period (fishing period 3 and 4 from 11–18 March 2024 and 5–19 April 2024, respectively).

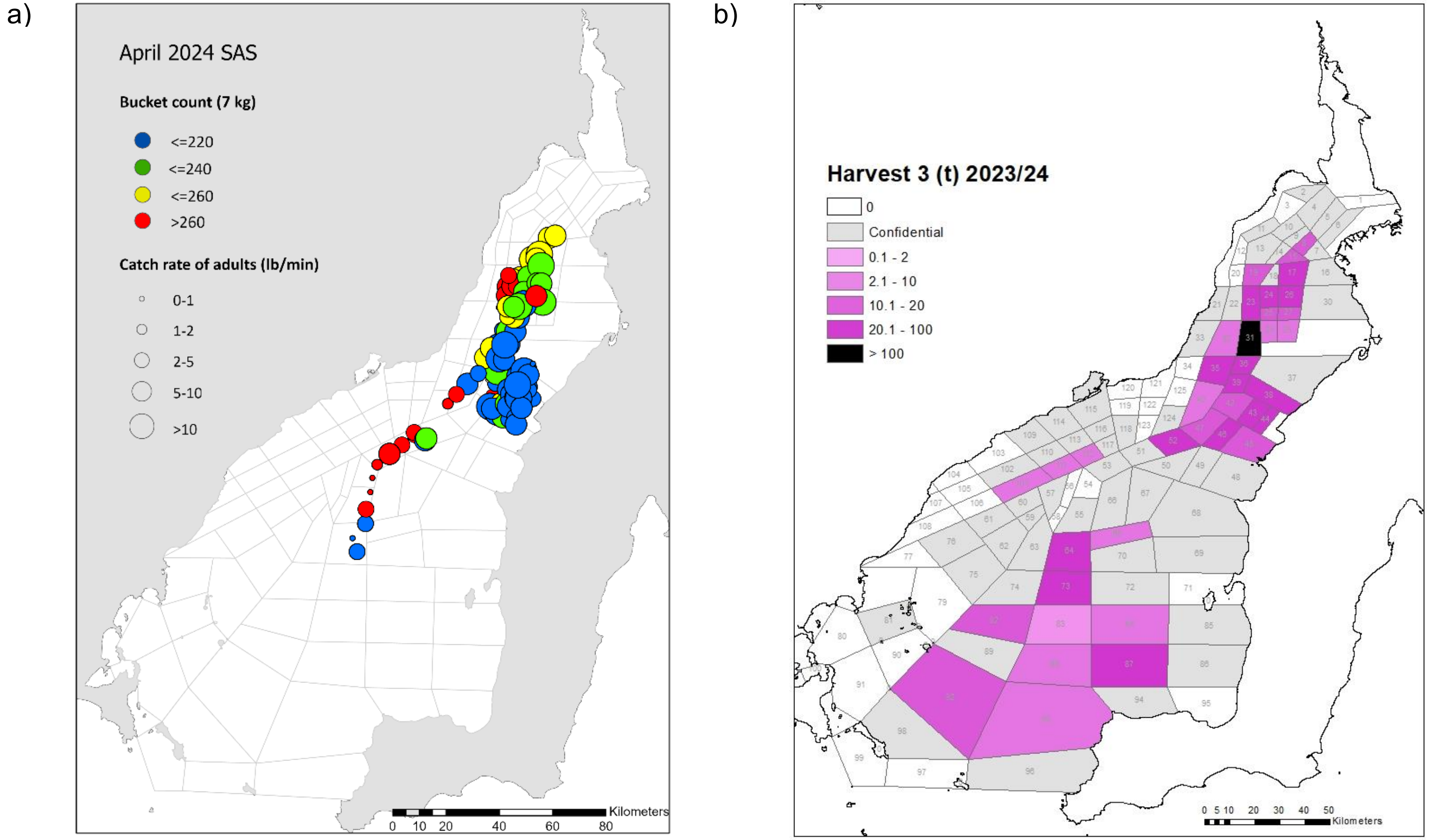


Figure A.7. (a) Results of 9 April 2024 survey and (b) subsequent harvest by block during the second harvest period (fishing period 5 and 6 from 5–18 May 2024 and 4–9 June 2024, respectively).

APPENDIX B. BYCATCH SURVEY RESULTS

a)

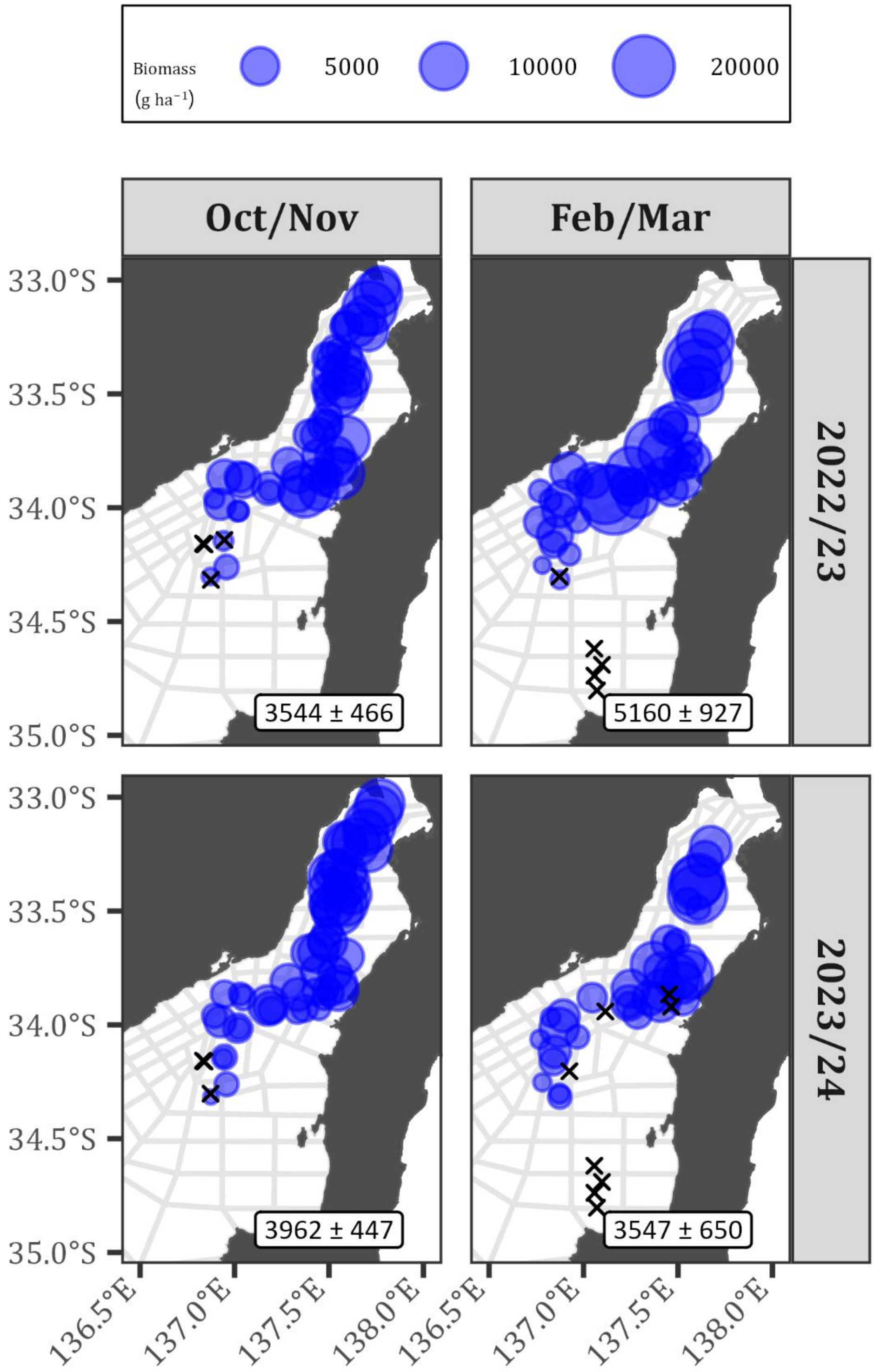


Figure B.1. Biomass (a) and abundance (b) of Blue Swimmer Crab sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

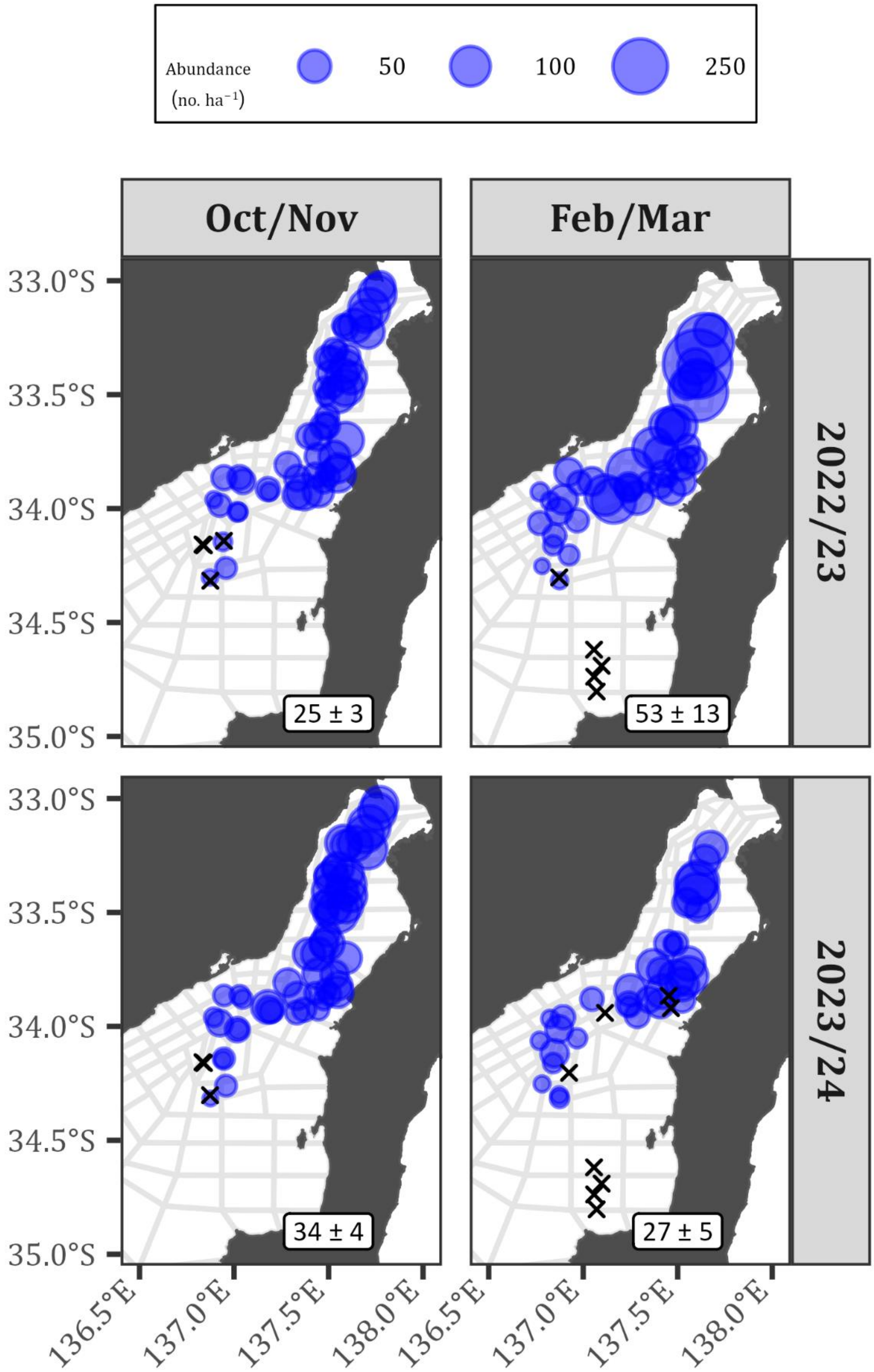


Figure B.1. cont. Biomass (a) and abundance (b) of Blue Swimmer Crab sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

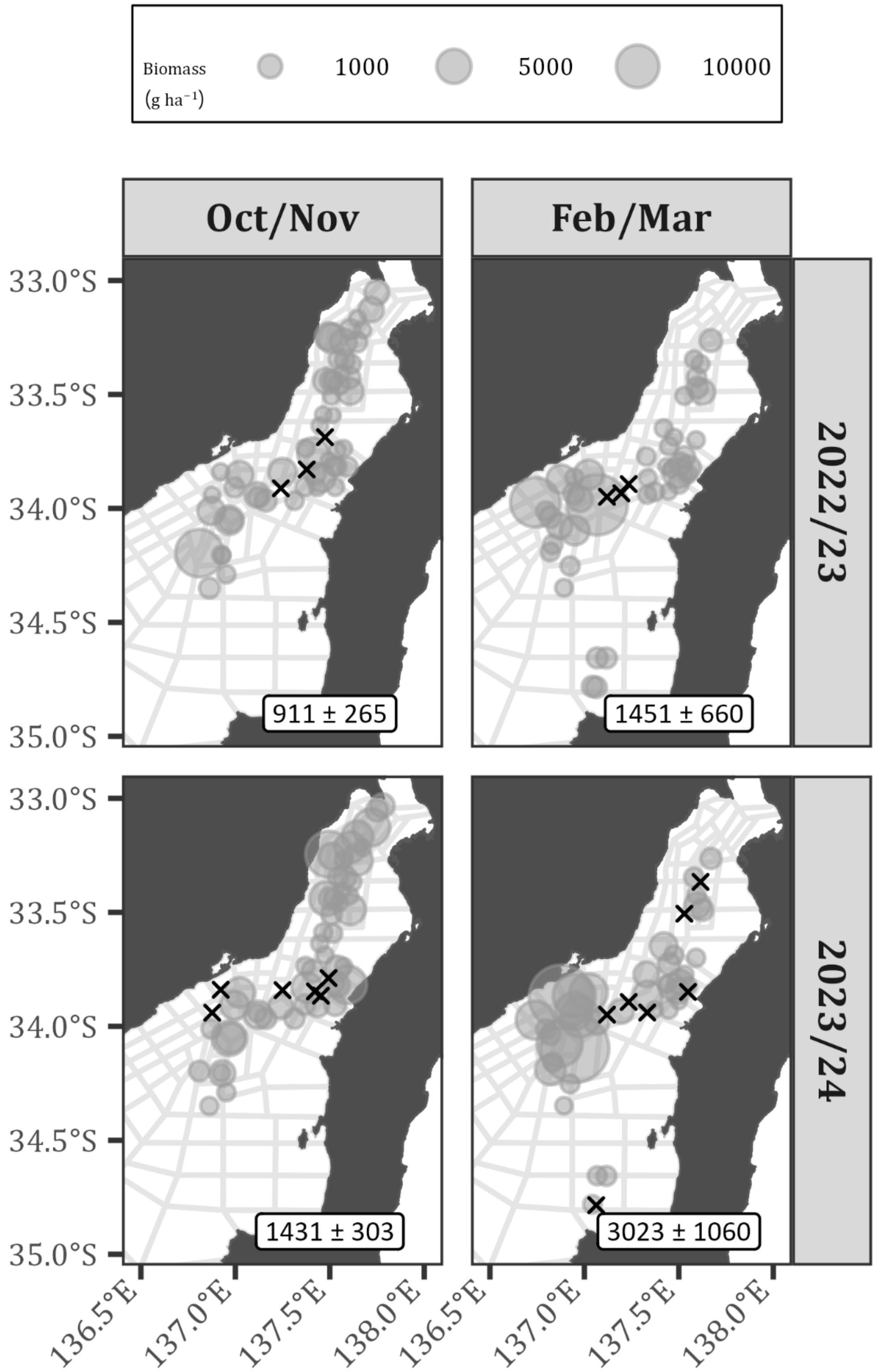


Figure B.2. Biomass (a) and abundance (b) of Skipjack Trevally sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

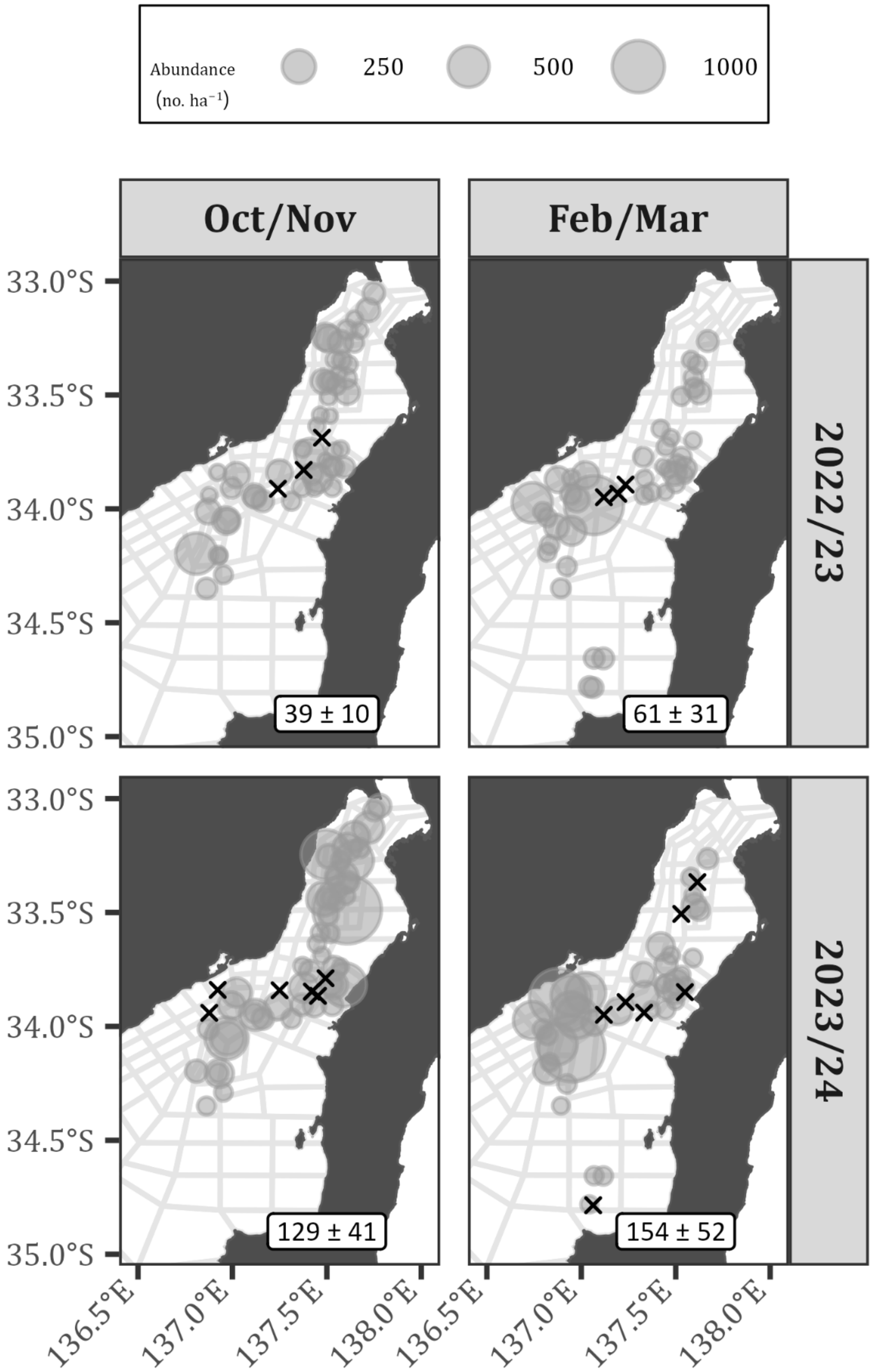


Figure B.2. cont. Biomass (a) and abundance (b) of Skipjack Trevally sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

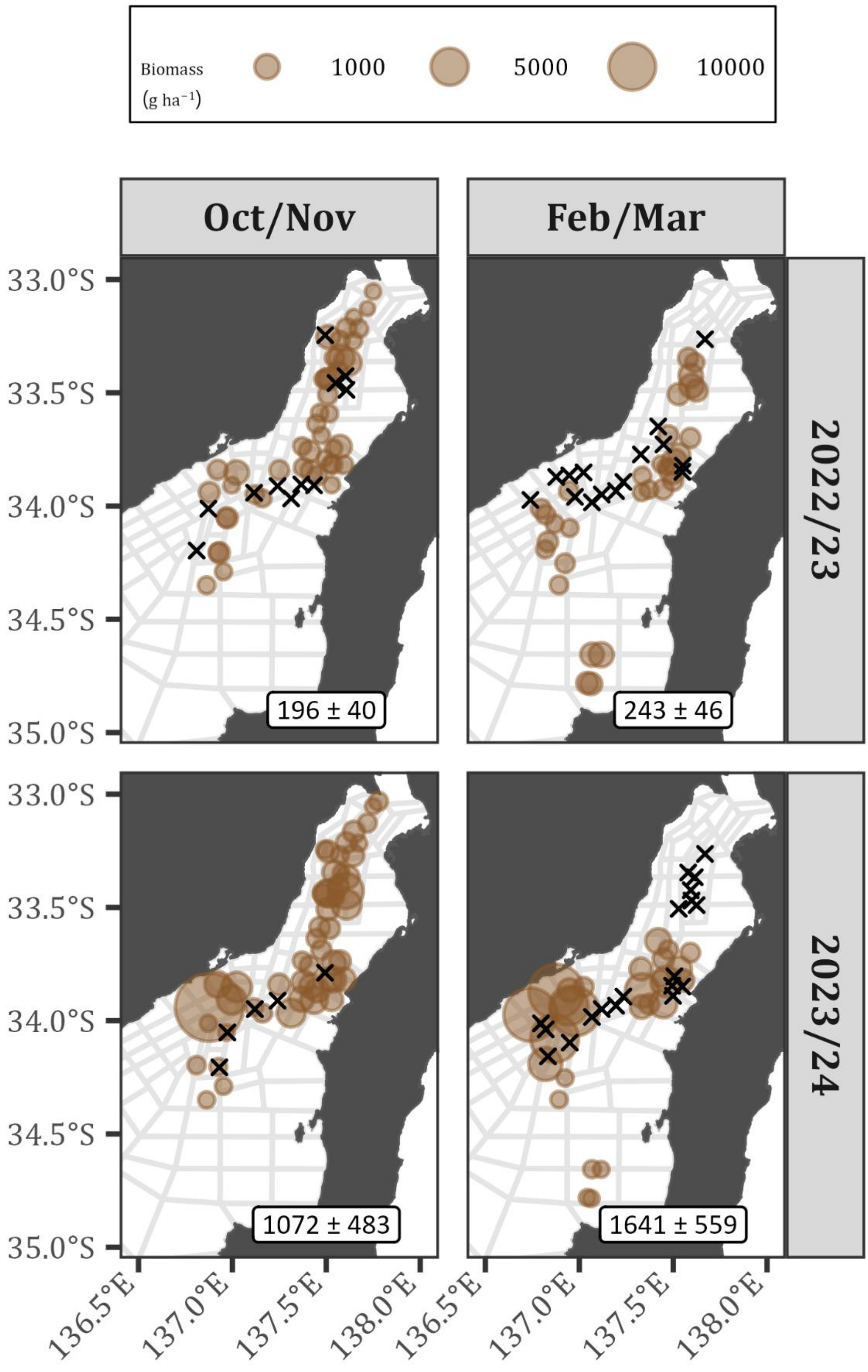


Figure B.3. Biomass (a) and abundance (b) of Rough Leatherjacket sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

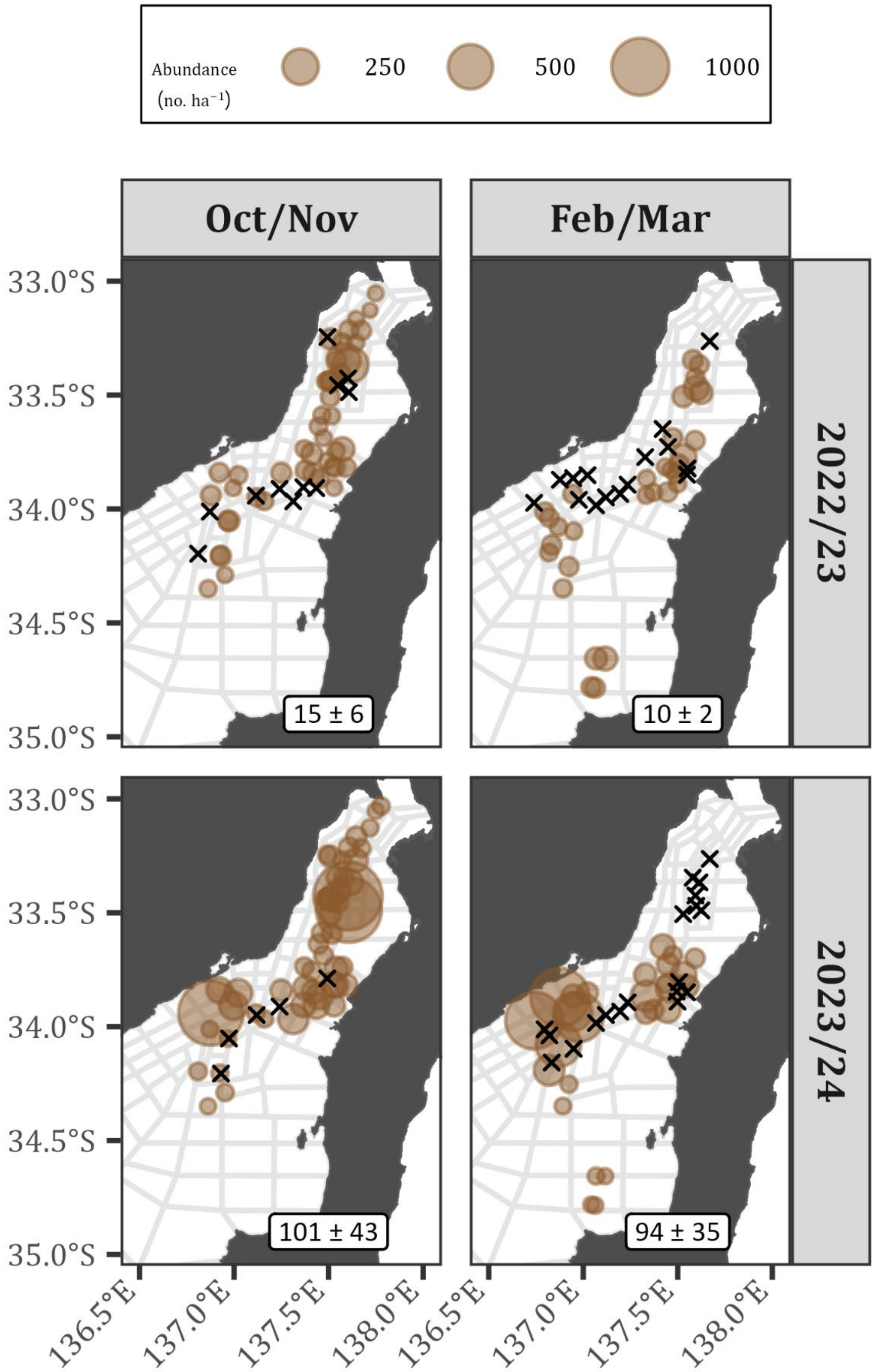


Figure B.3. cont. Biomass (a) and abundance (b) of Rough Leatherjacket sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

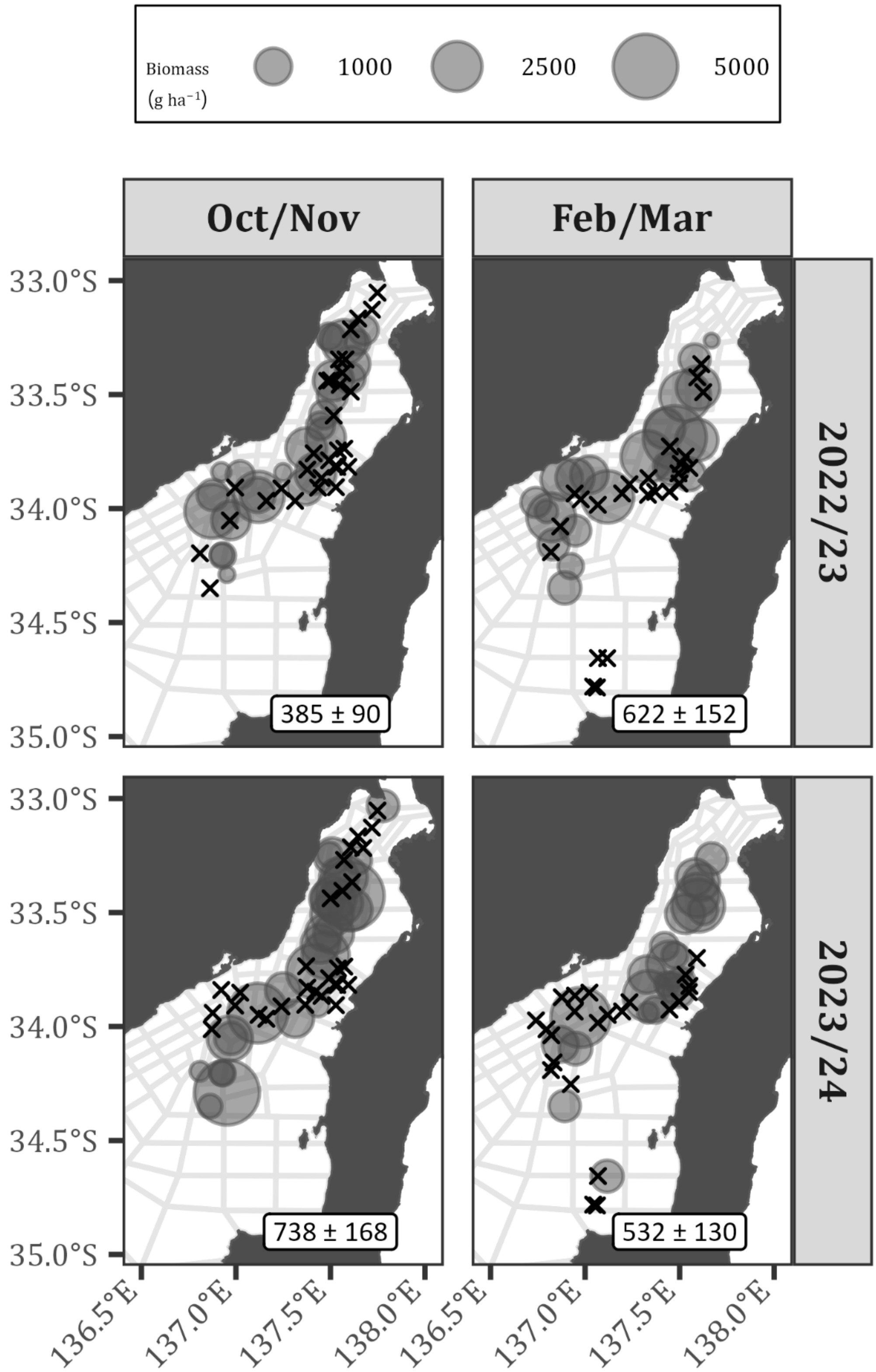


Figure B.4. Biomass (a) and abundance (b) of Port Jackson Shark sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

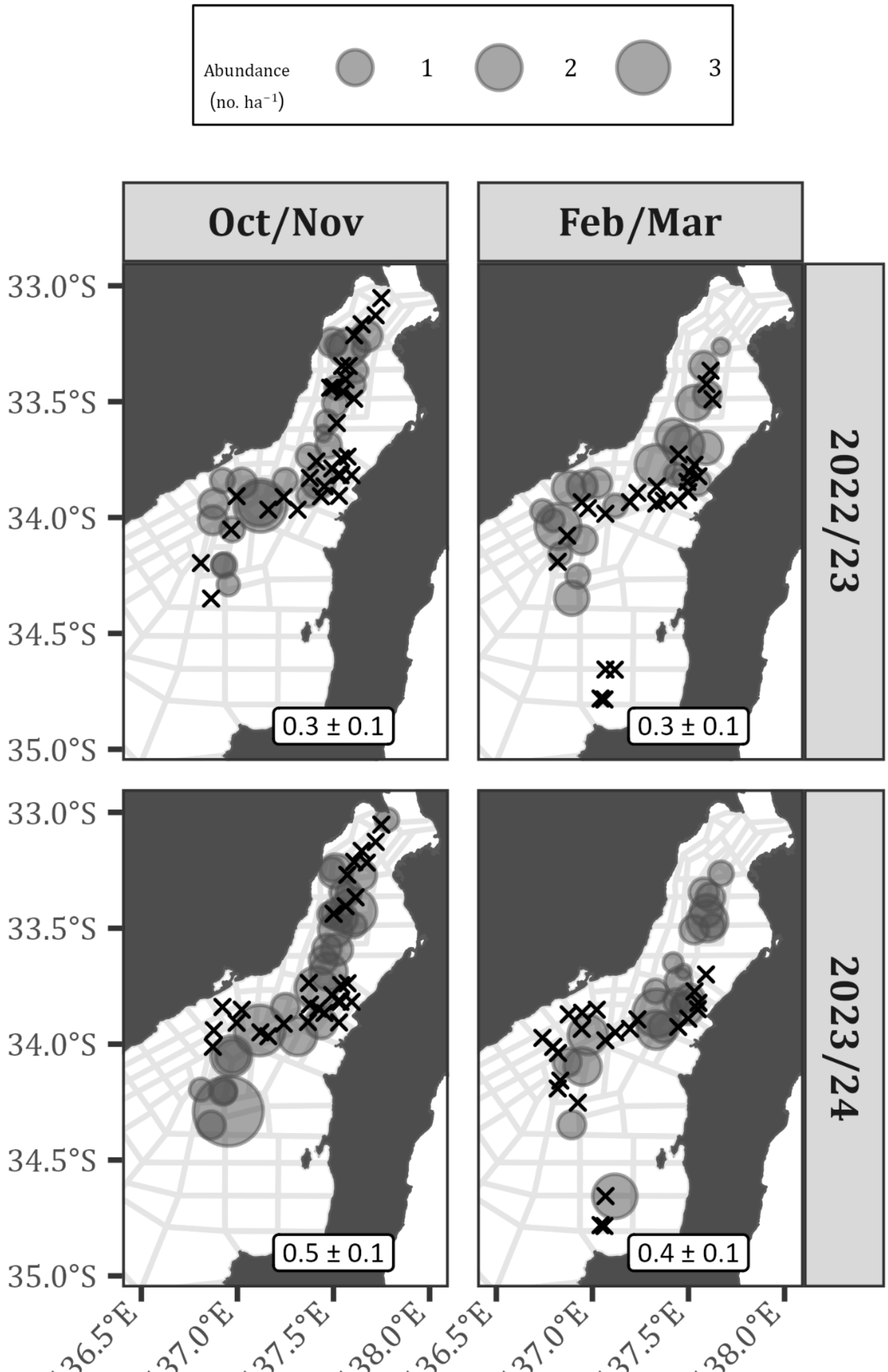


Figure B.4. cont. Biomass (a) and abundance (b) of Port Jackson Shark sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

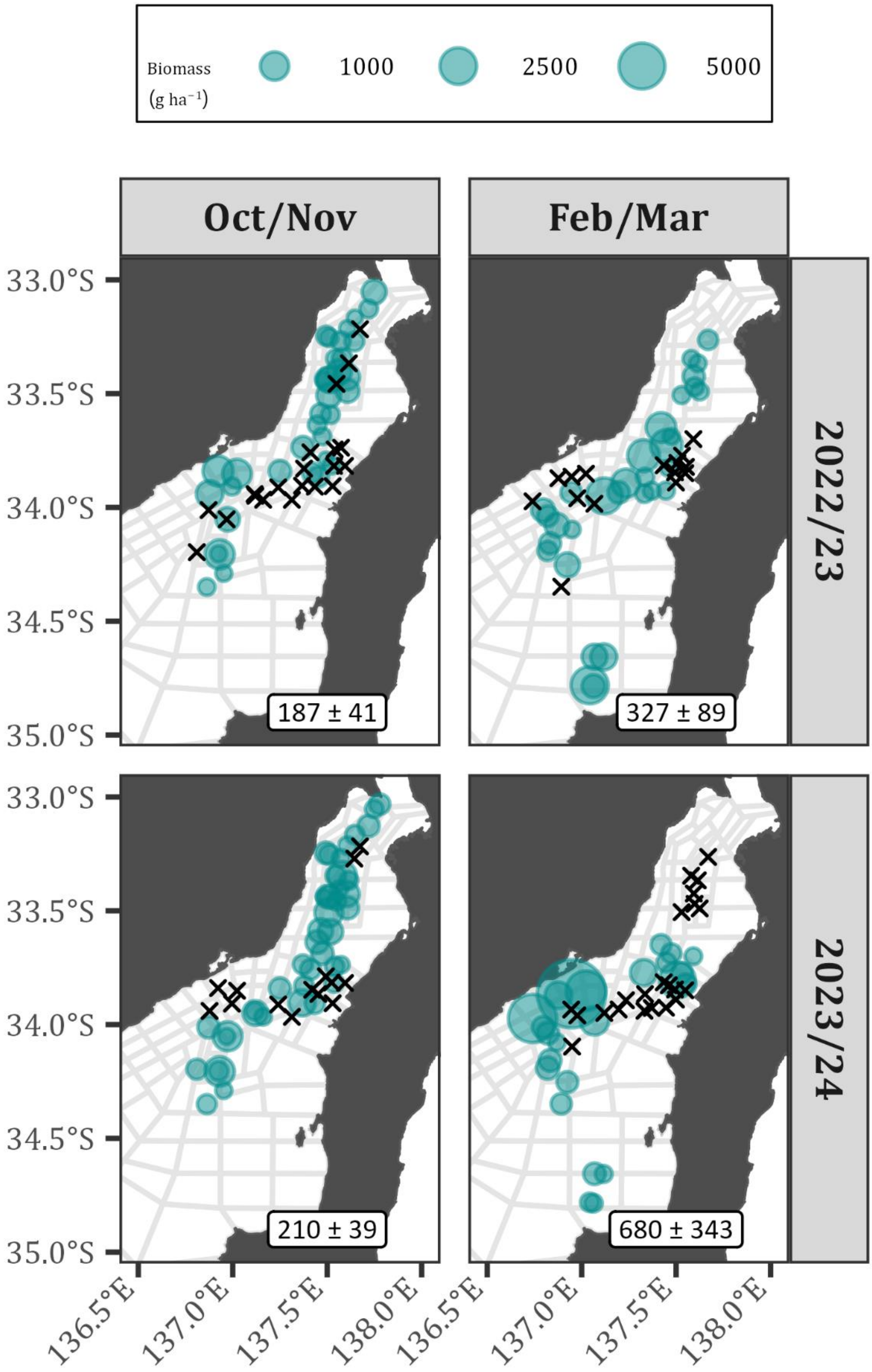


Figure B.5. Biomass (a) and abundance (b) of Bluefin Leatherjacket sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

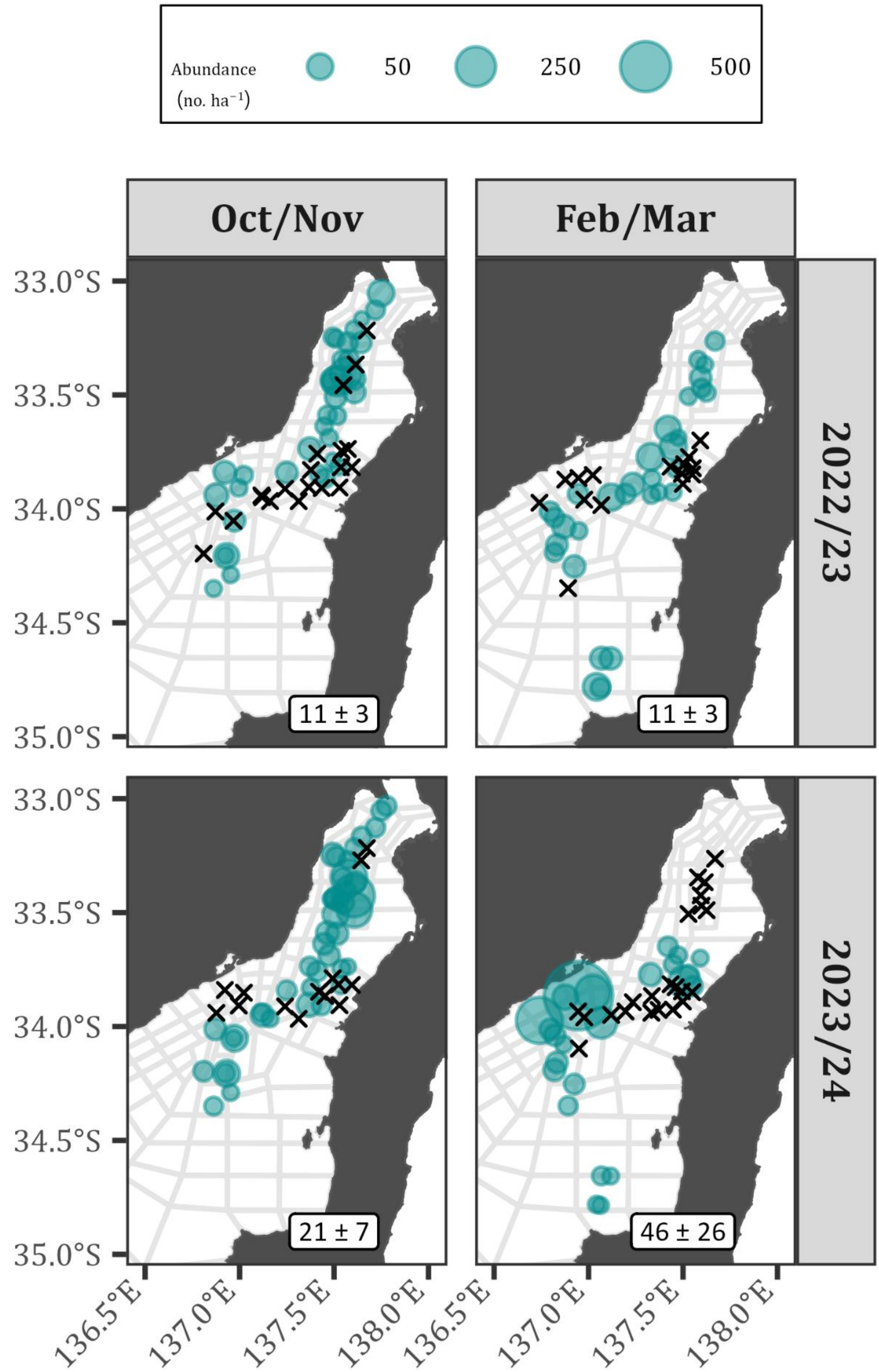


Figure B.5. cont. Biomass (a) and abundance (b) of Bluefin Leatherjacket sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

a)

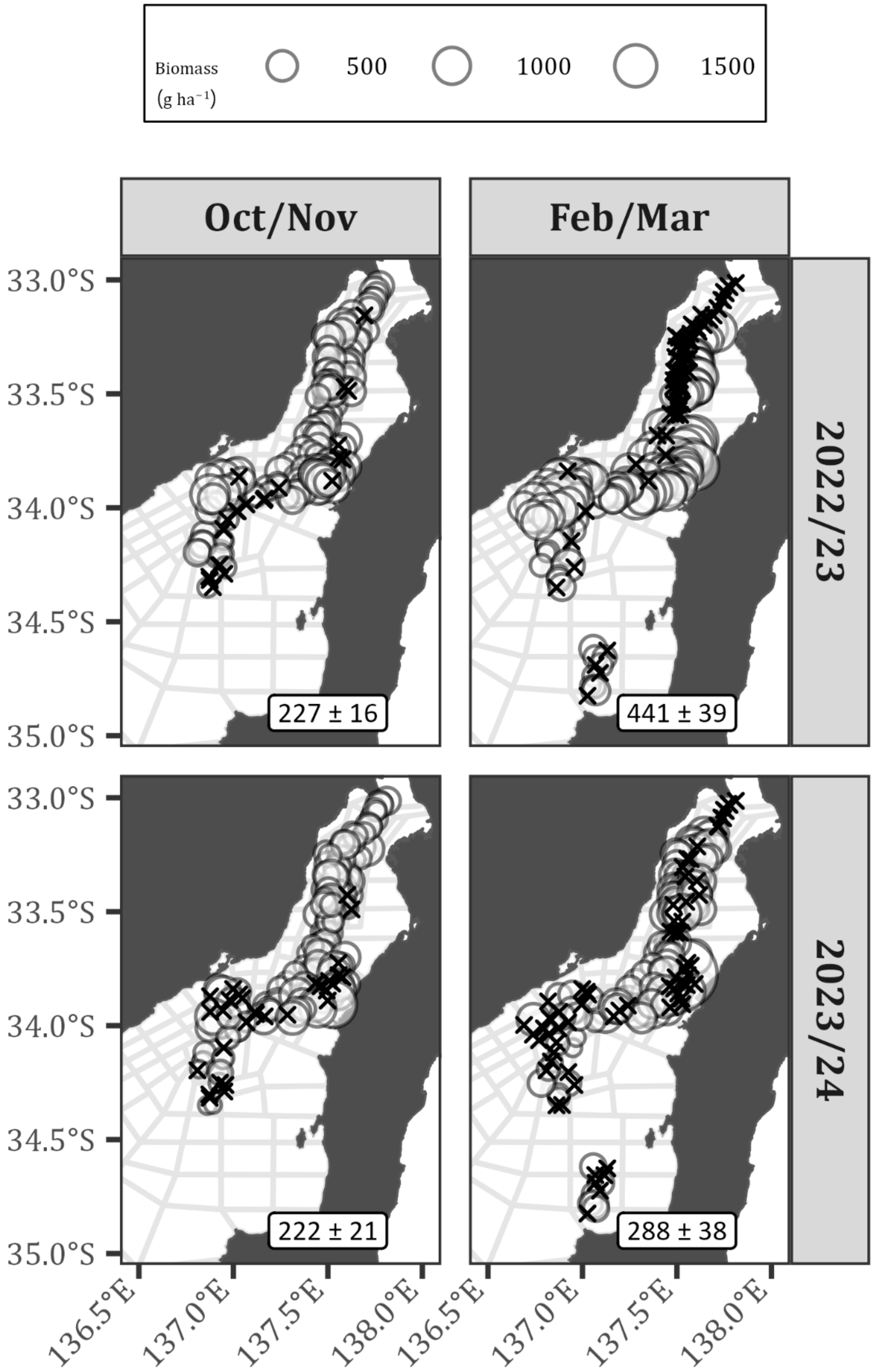


Figure B.6. Biomass (a) and abundance (b) of Southern Calamari sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

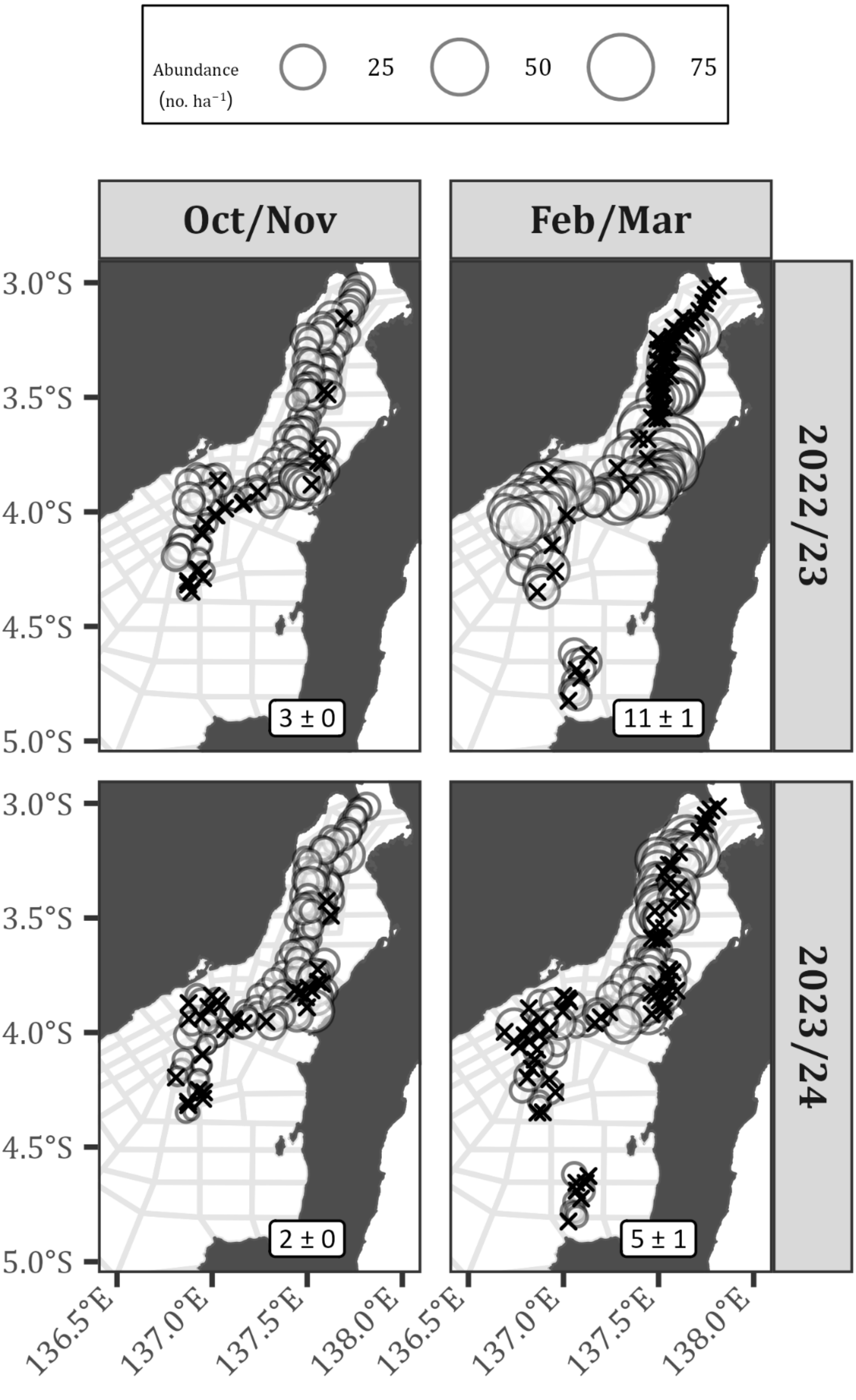


Figure B.6. cont. Biomass (a) and abundance (b) of Southern Calamari sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

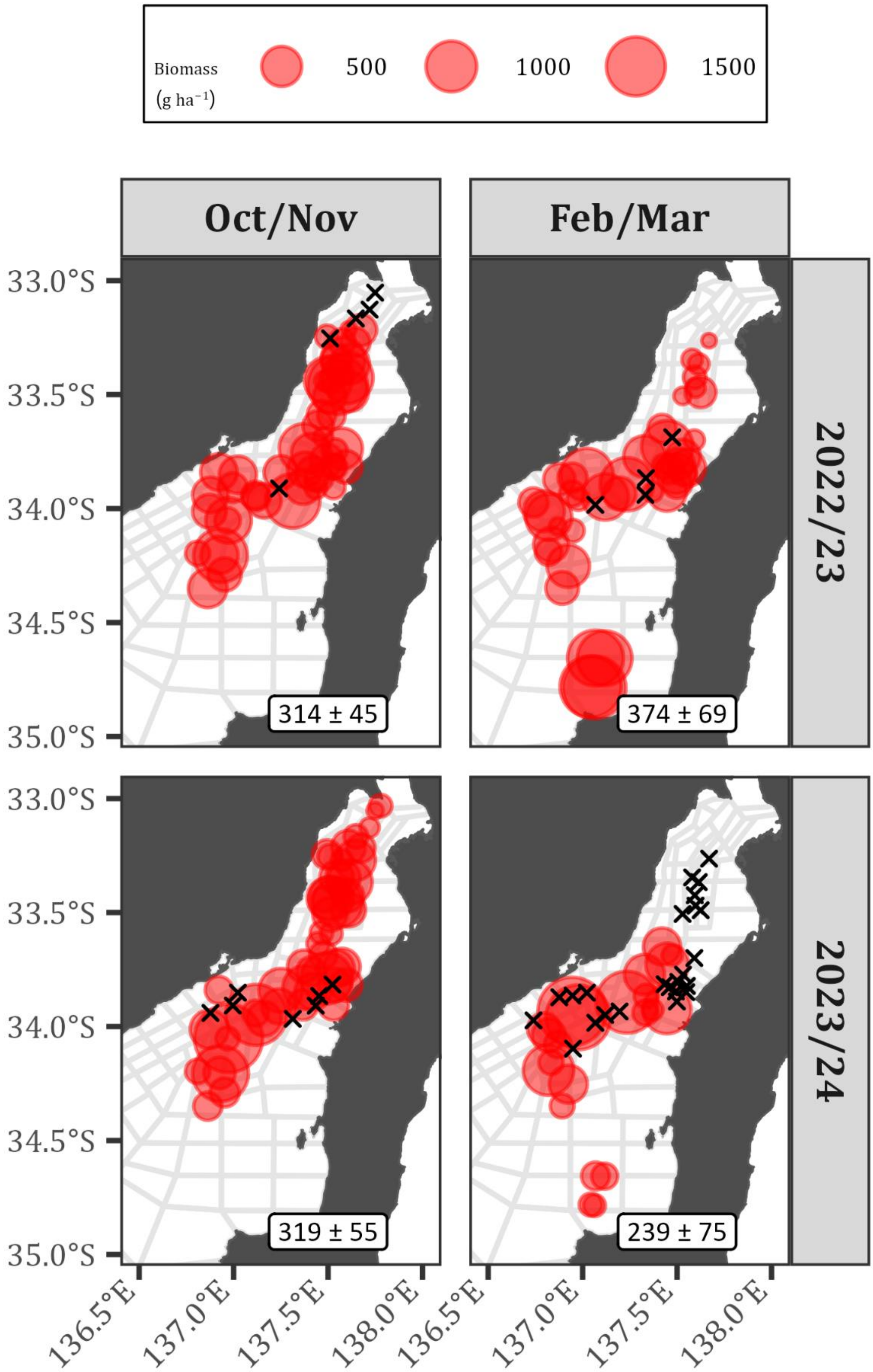


Figure B.7. Biomass (a) and abundance (b) of Bluespotted Goatfish sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

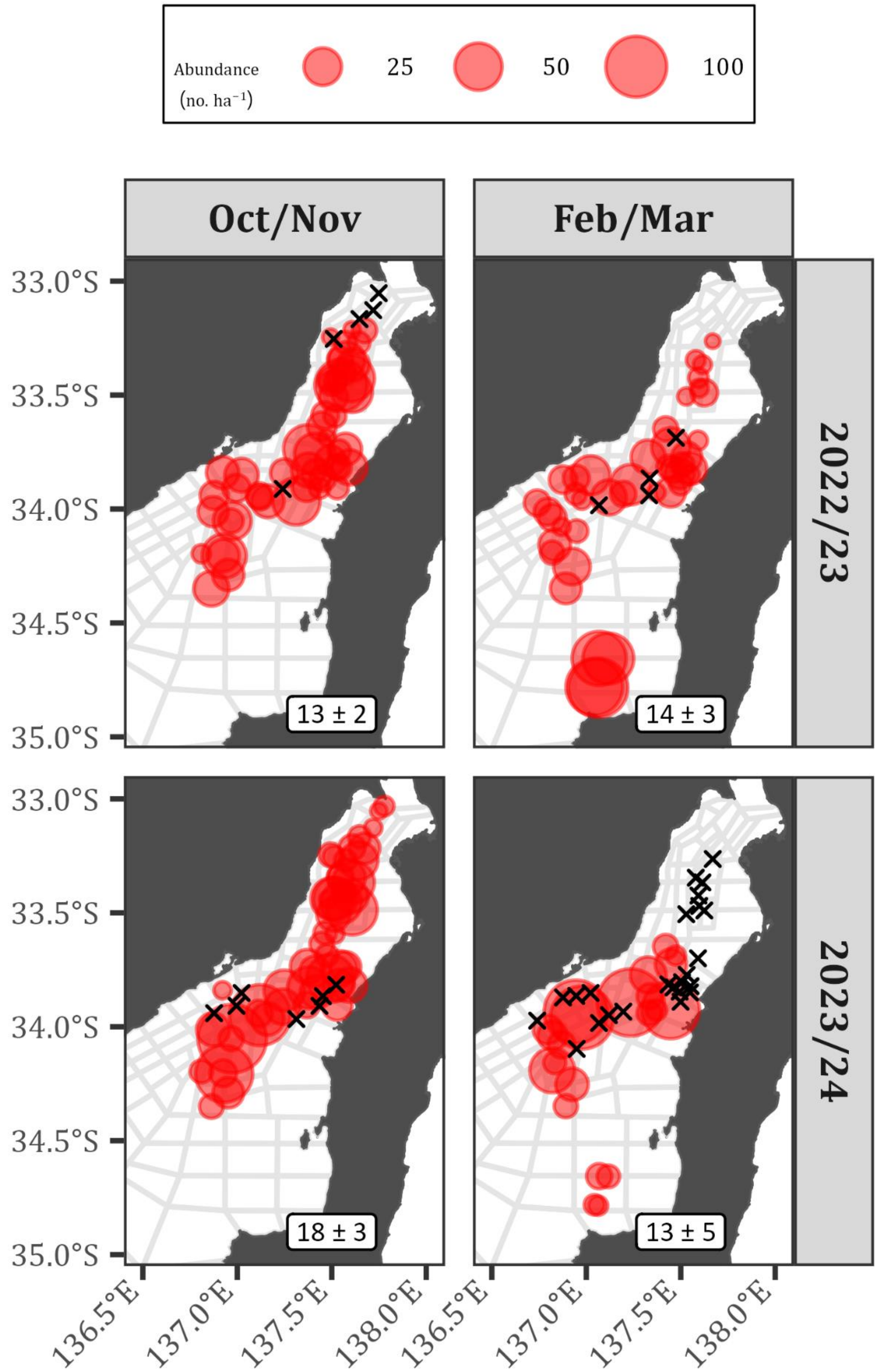


Figure B.7. cont. Biomass (a) and abundance (b) of Bluespotted Goatfish sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

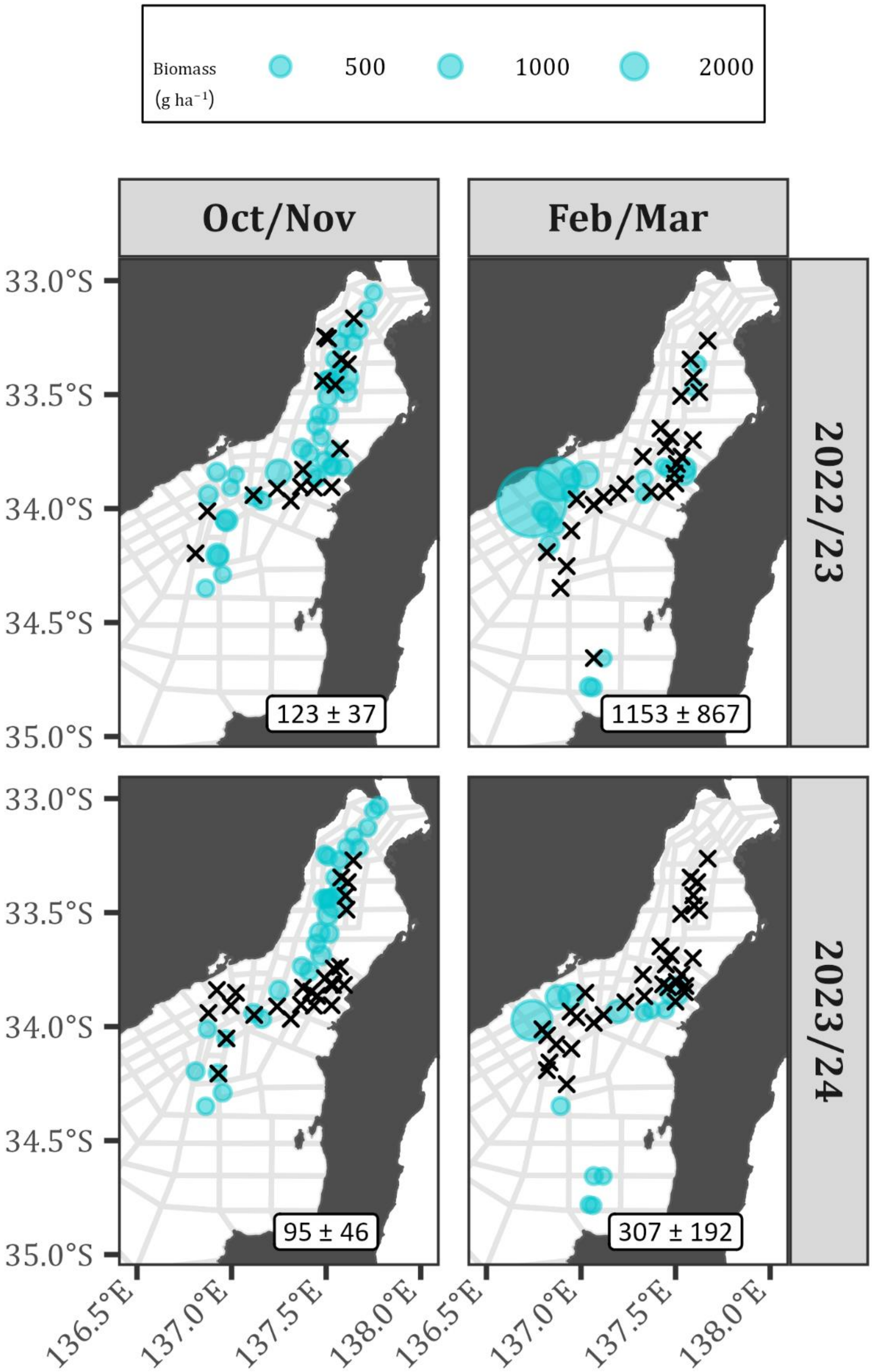


Figure B.8. Biomass (a) and abundance (b) of Toothbrush Leatherjacket sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

b)

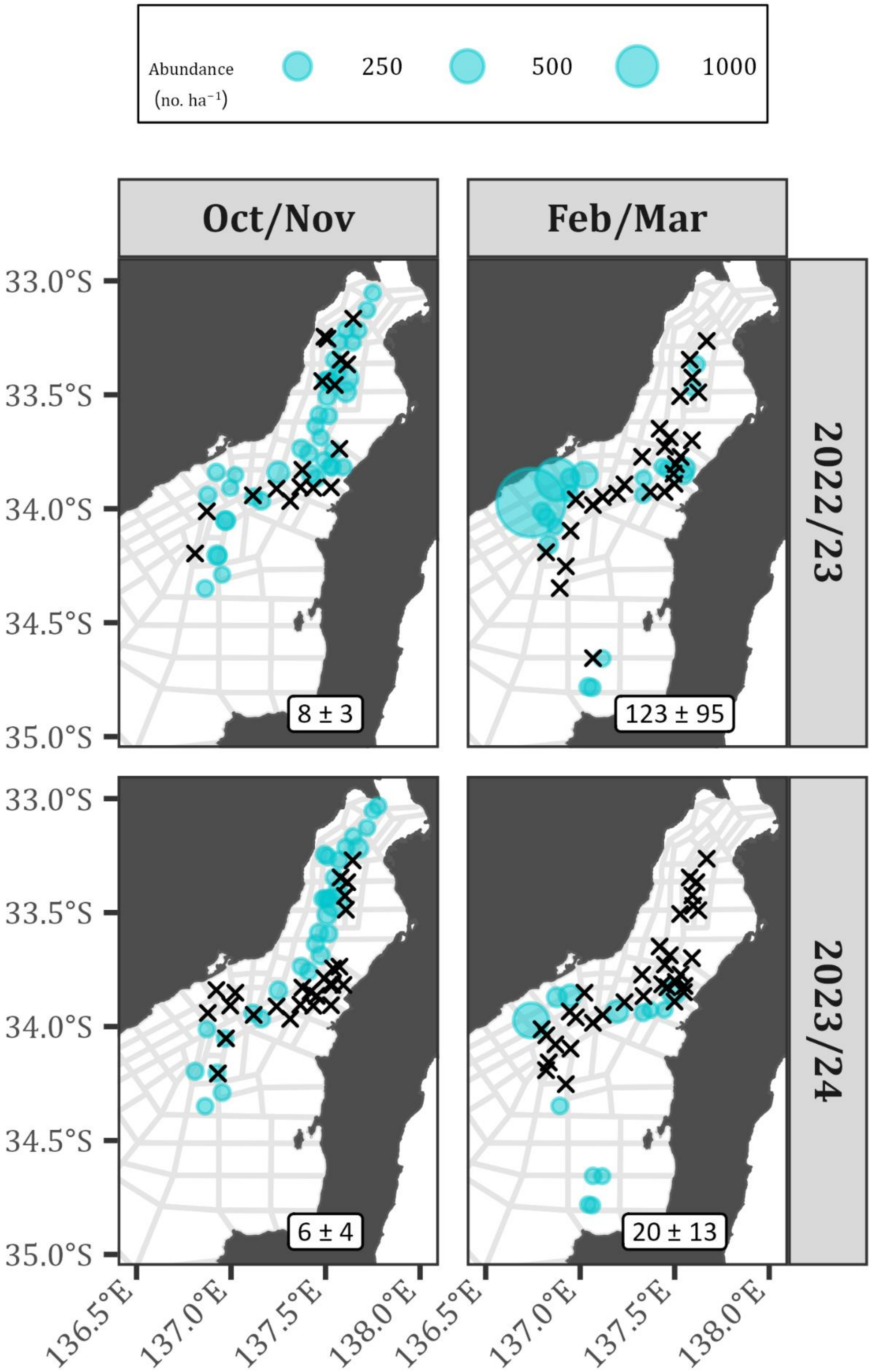


Figure B.8. cont. Biomass (a) and abundance (b) of Toothbrush Leatherjacket sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

a)

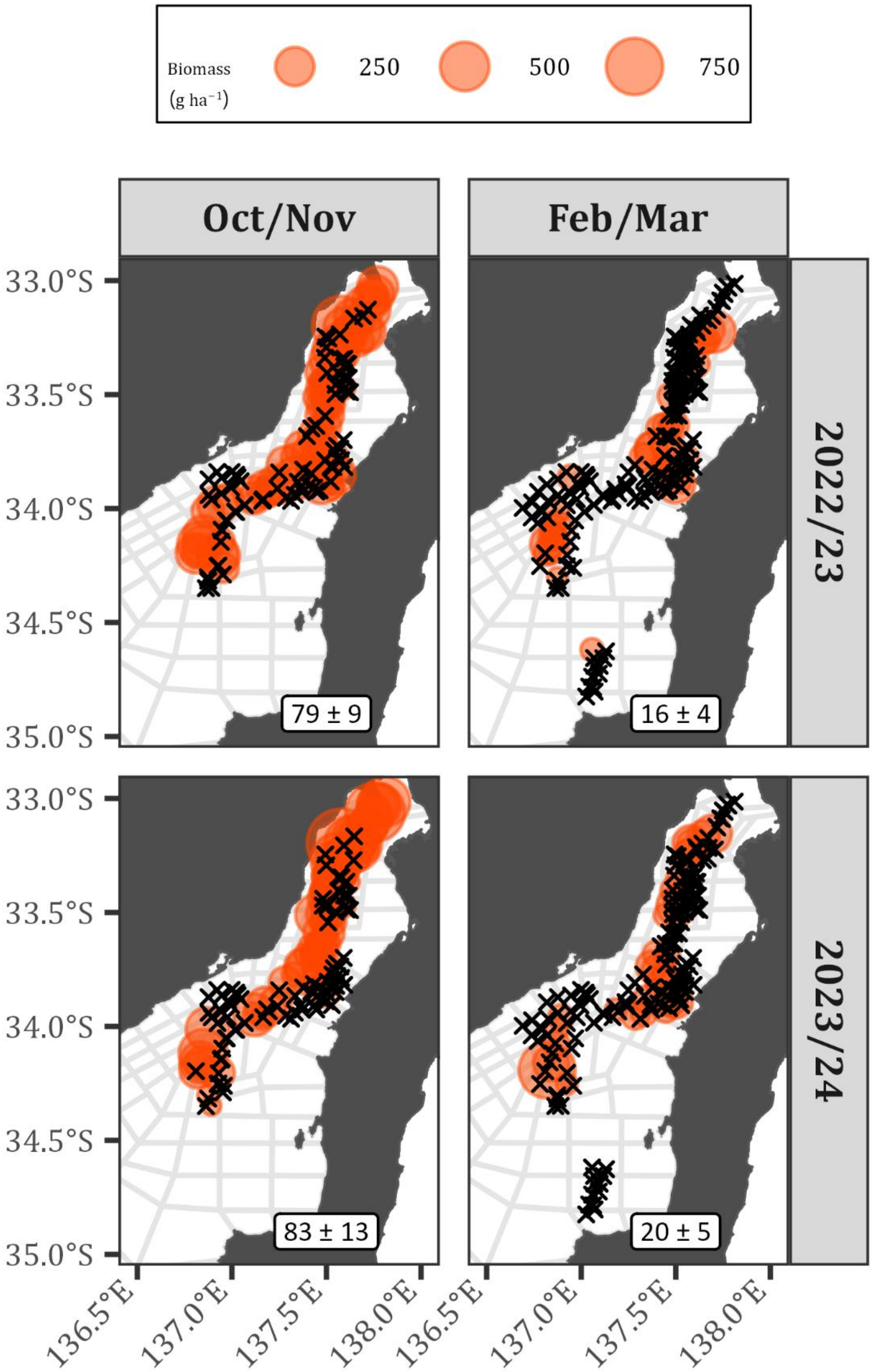


Figure B.9. Biomass (a) and abundance (b) of Eastern Balmain Bug sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

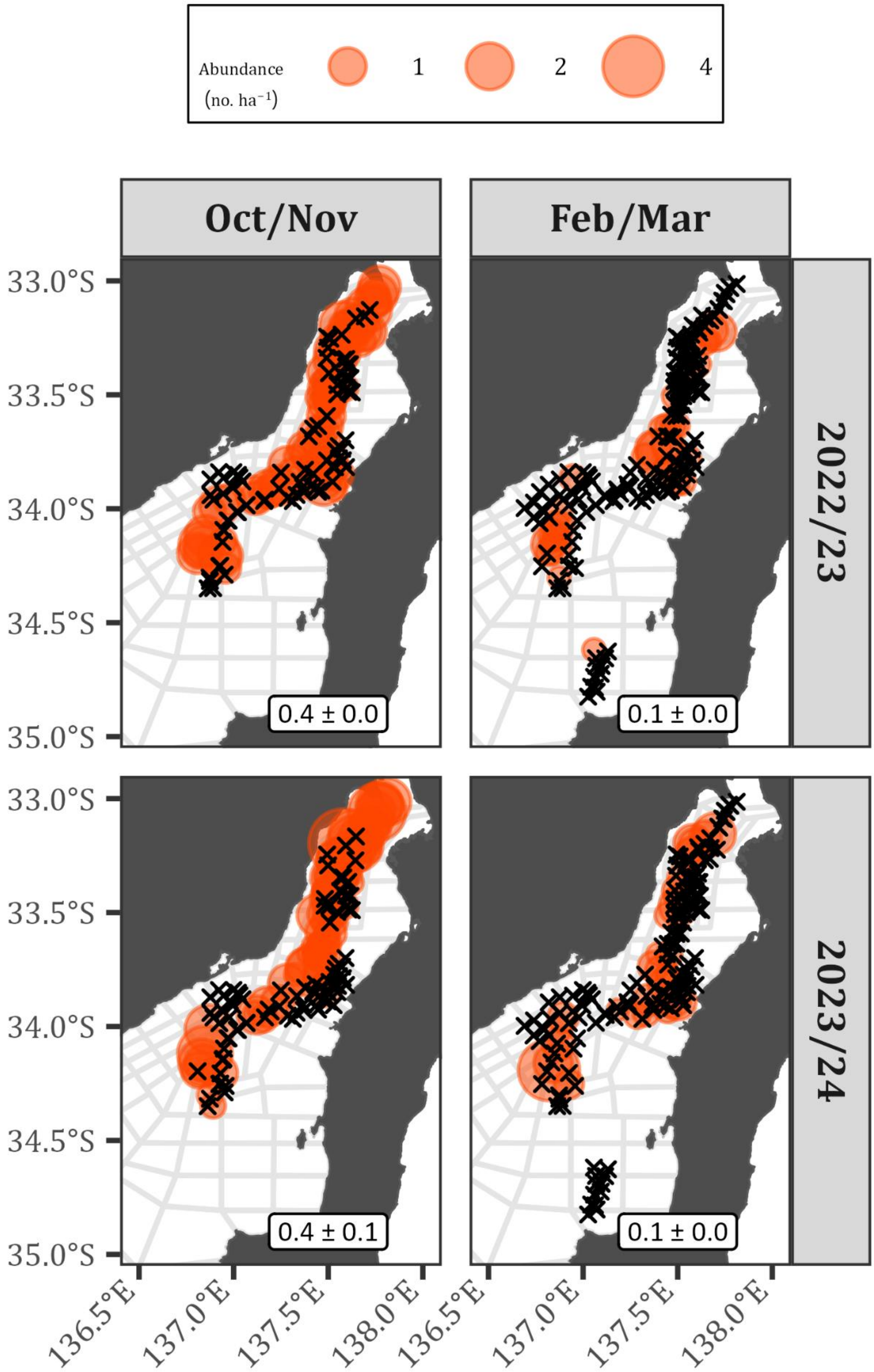


Figure B.9. cont. Biomass (a) and abundance (b) of Eastern Balmain Bug sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

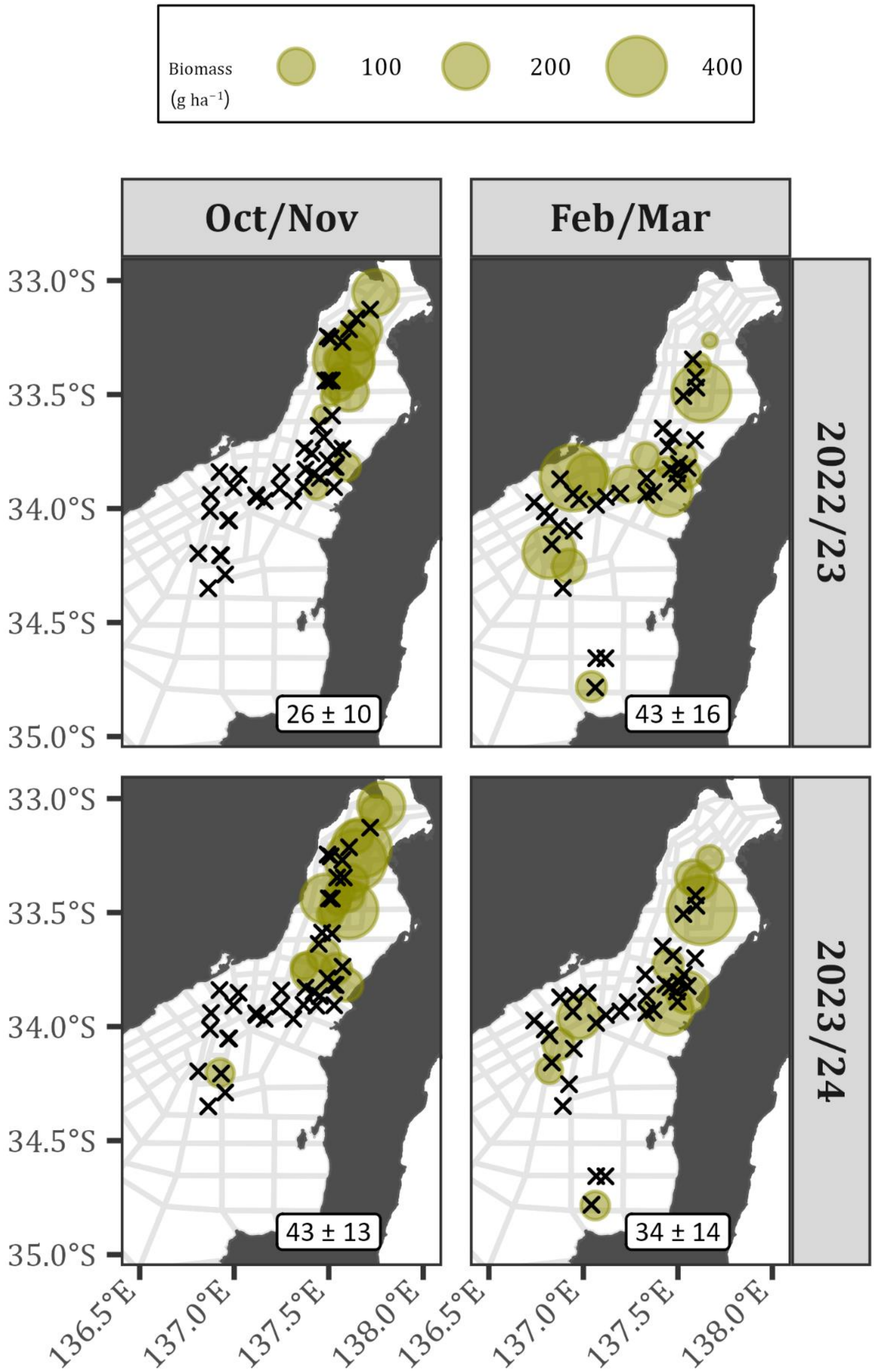


Figure B.10. Biomass (a) and abundance (b) of King George Whiting sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

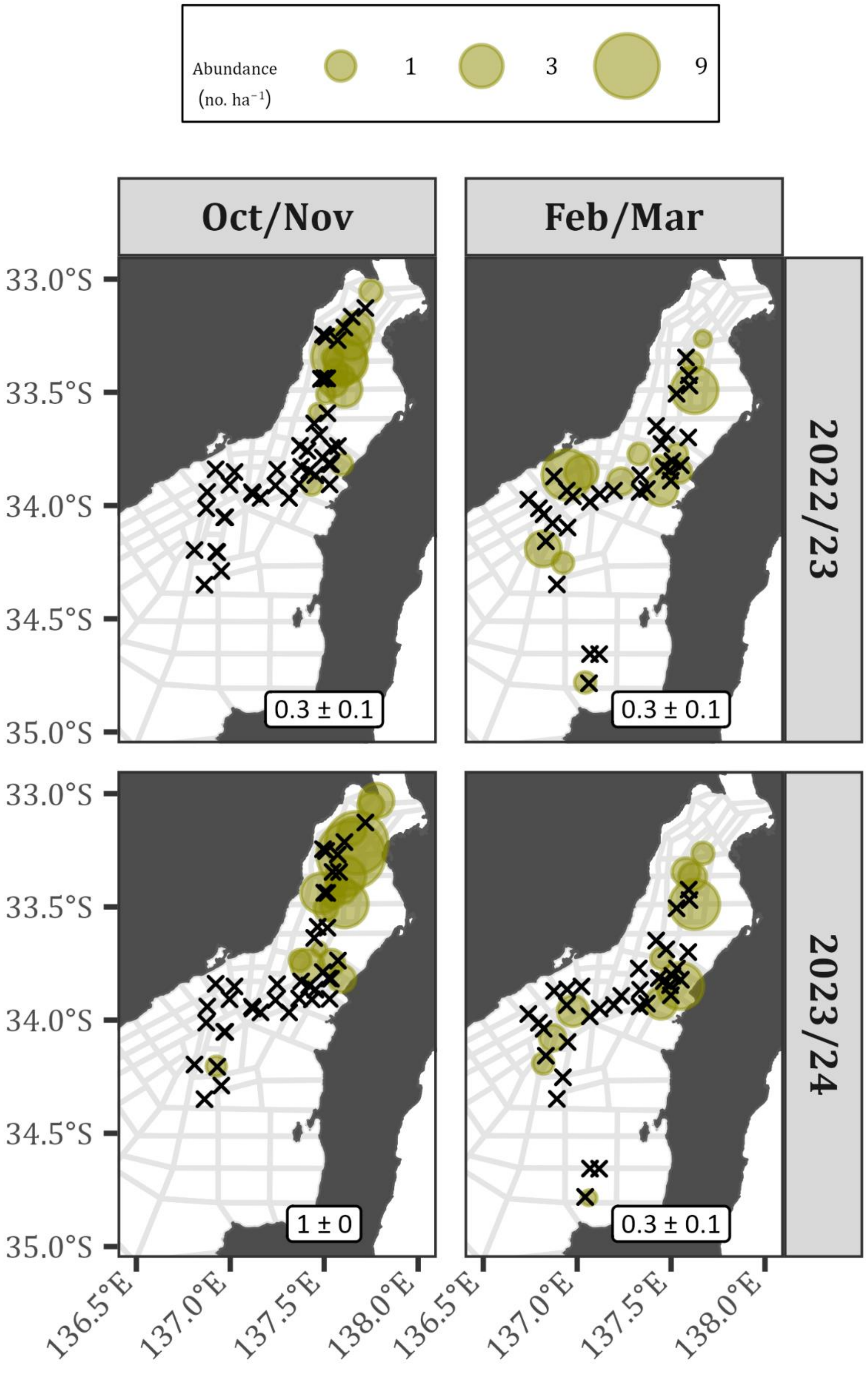


Figure B.10. cont. Biomass (a) and abundance (b) of King George Whiting sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

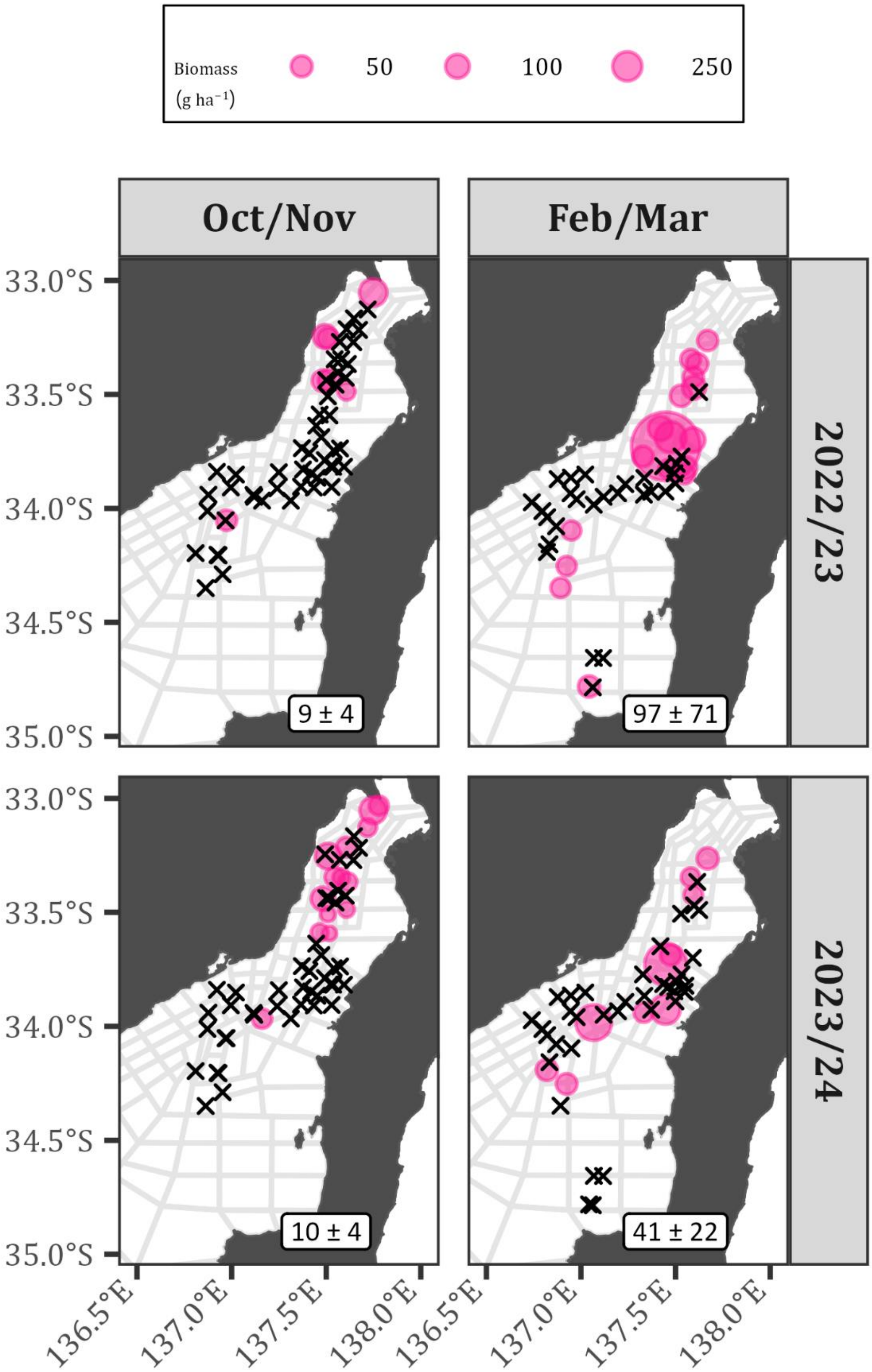


Figure B.11. Biomass (a) and abundance (b) of Snapper sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

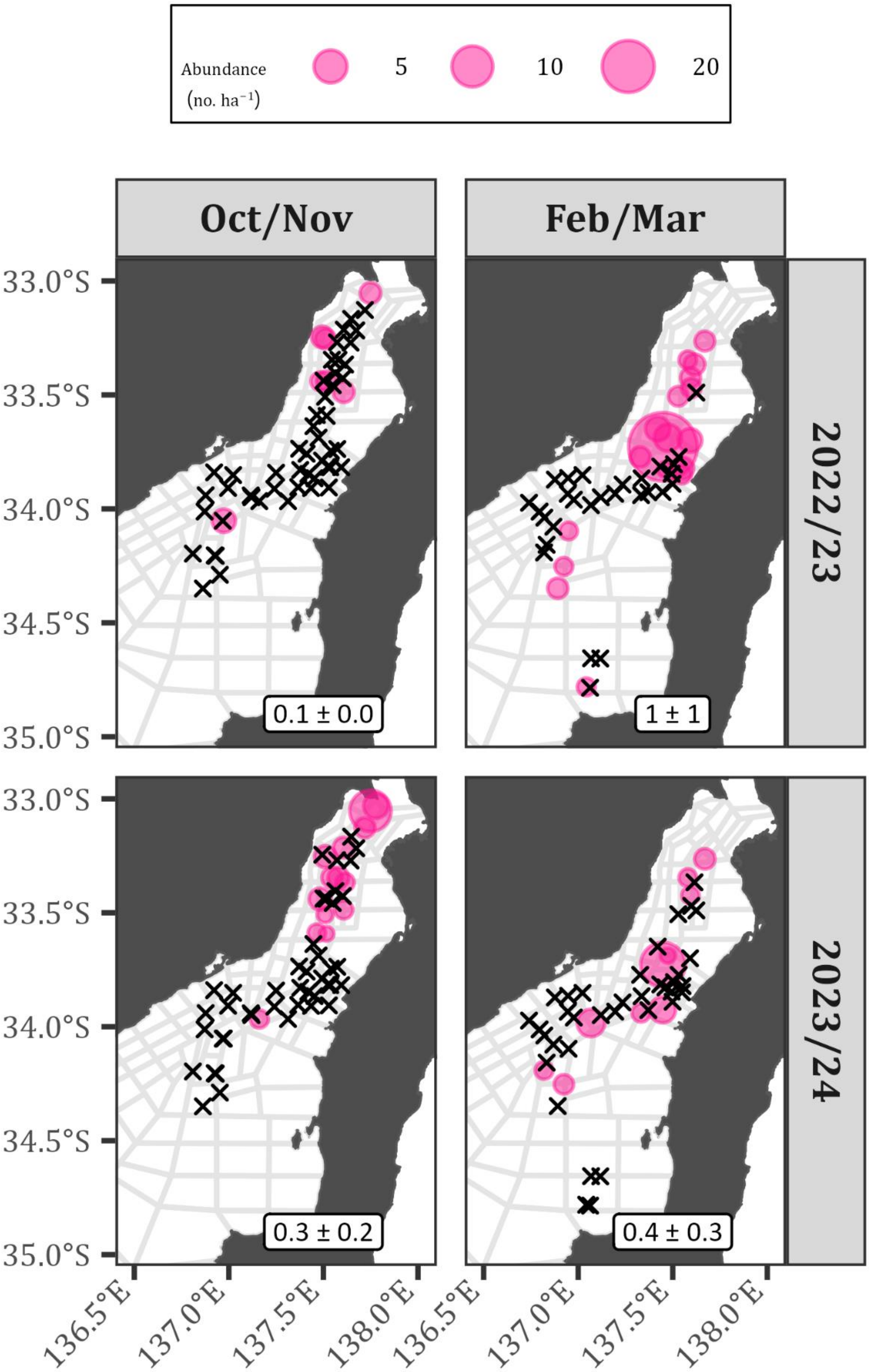


Figure B.11. cont. Biomass (a) and abundance (b) of Snapper sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

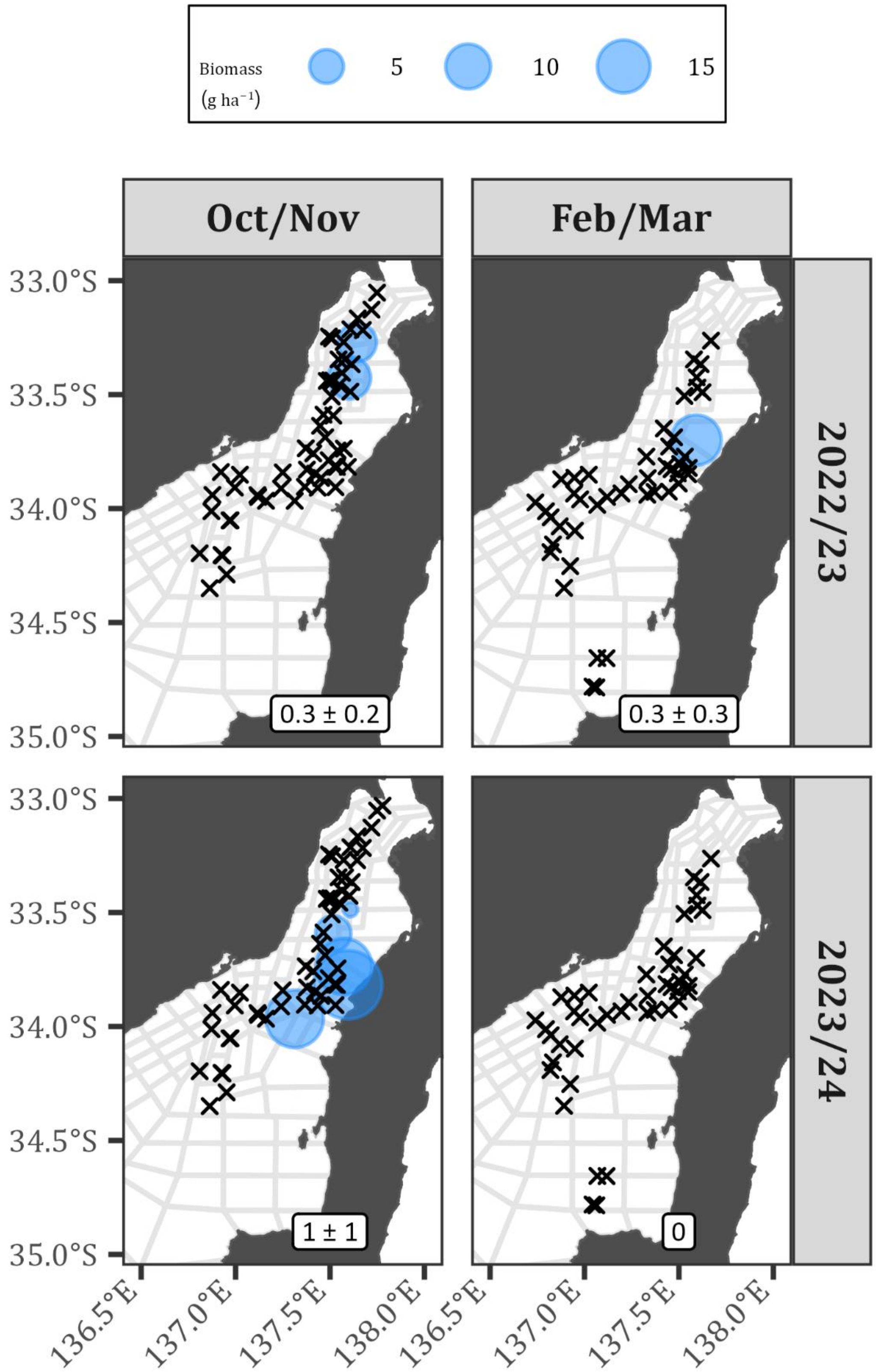


Figure B.12. Biomass (a) and abundance (b) of Southern Garfish sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

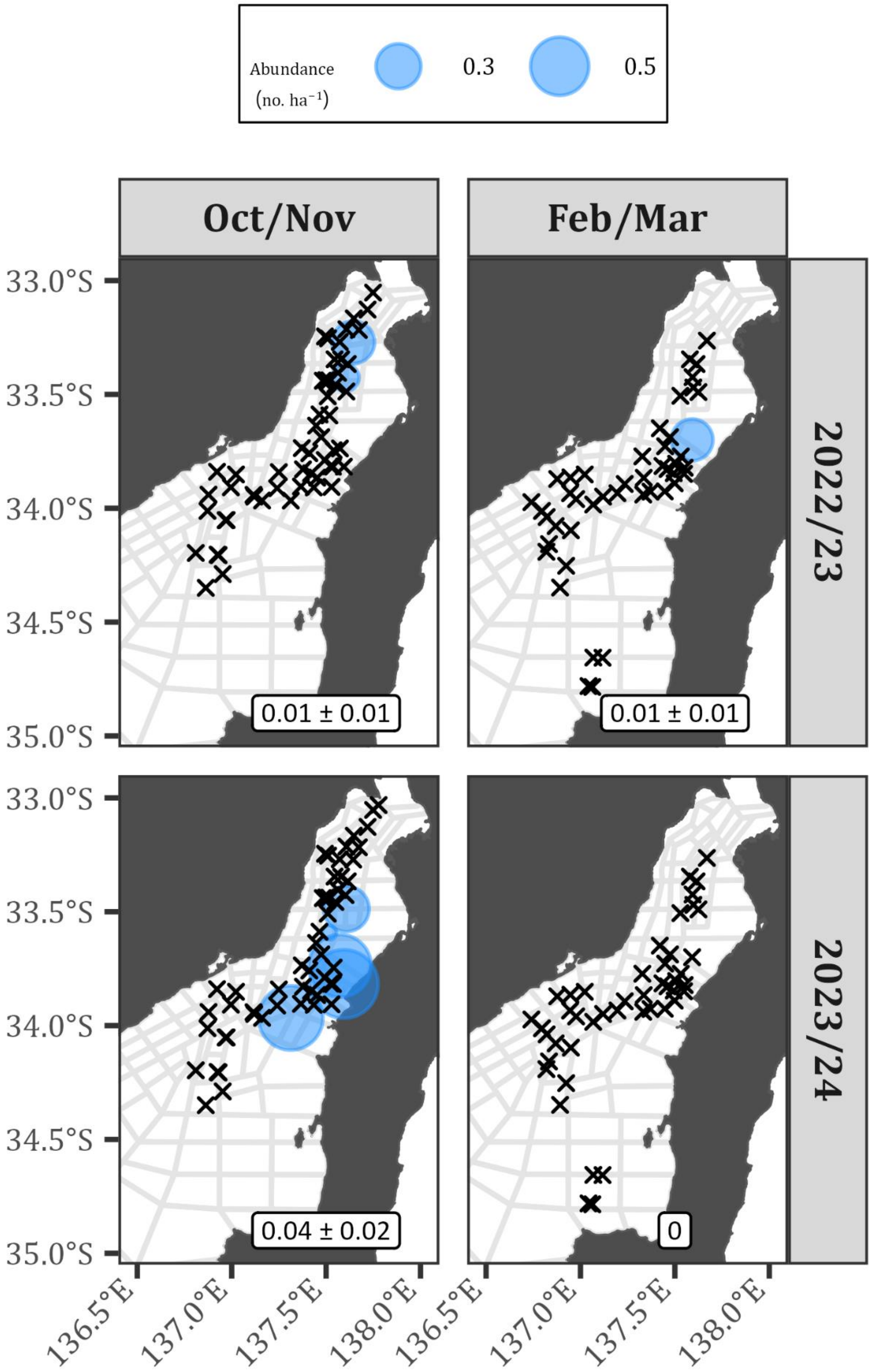


Figure B.12. cont. Biomass (a) and abundance (b) of Southern Garfish sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

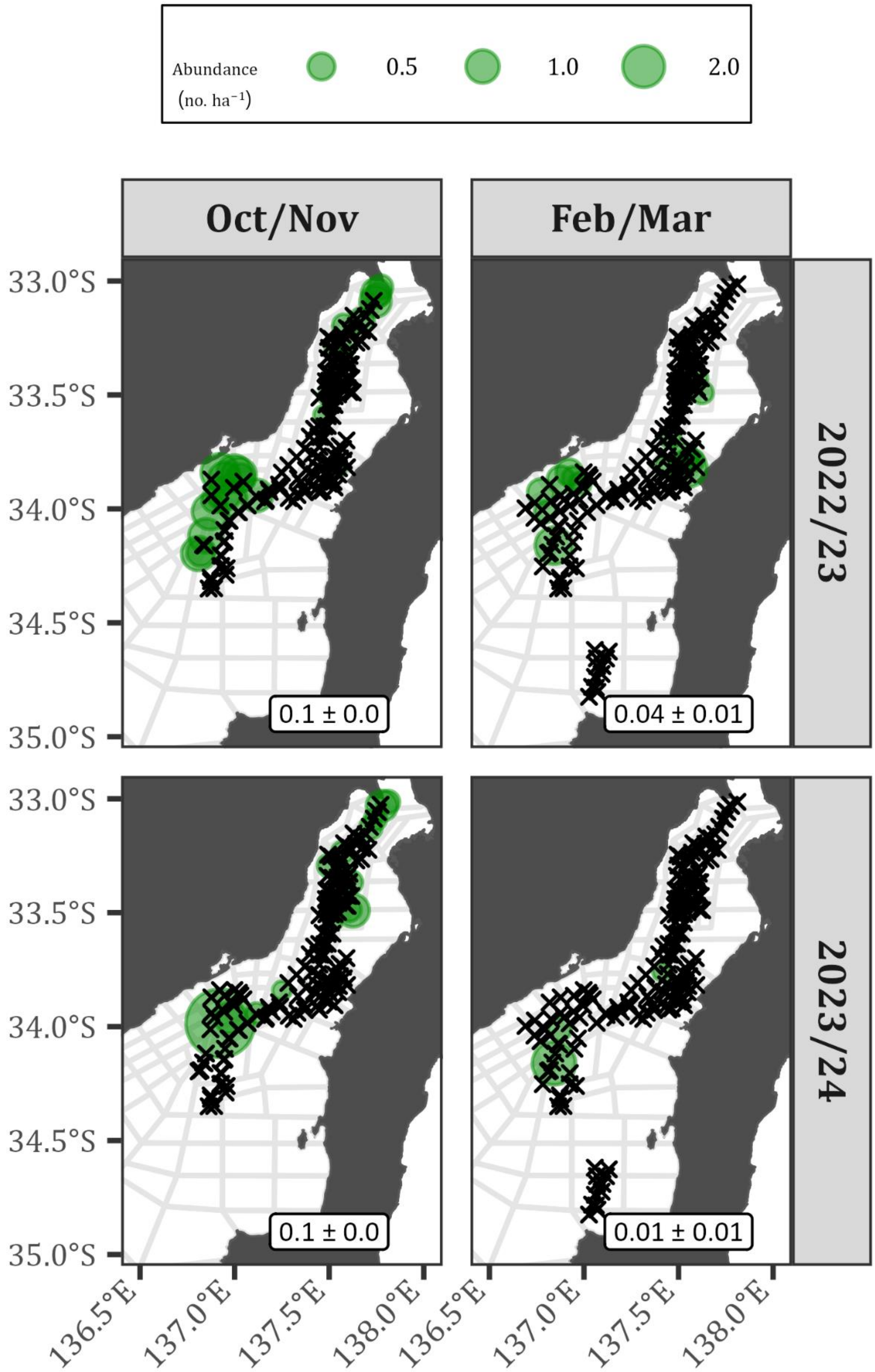


Figure B.13. Abundance of Syngnathids sampled by the SGPF during October/November and February/March surveys in 2022/23 and 2023/24. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

APPENDIX C. BYCATCH CORRECTION 2019/20 TO 2023/24

A calculation error in the standardisation of bycatch to relative biomass and abundance per swept area (grams and number per hectare [ha], respectively) was detected and corrected for two assessment periods: Oct/Nov 2019 to Feb/Mar 2022 and Oct/Nov 2022 to Feb/Mar 2024. The consequences of the calculation error were analysed and are presented in this appendix.

What was the error and its potential implication on the results?

To calculate relative abundance and biomass, the swept area (A) is calculated using a modification of the formula established for previous gulf-wide trawl bycatch surveys (Currie et al. 2009, Burnell et al. 2015):

$$A = (H * S * D) / 10{,}000$$

where H is the headline length of the net (i.e. 14.63 = 0.5 × 29.26 m [maximum permissible headline length for a double otter-trawl configuration]), S is the net spread factor (i.e. 0.75 from Carrick 1996), D is the distance trawled (m), and division by 10,000 converts the area from m^2 to ha. The formula was modified to account for N, the number of nets used in sampling, as it varies between 1 and 2 nets for bycatch monitoring surveys (Table C.1).

In prior reports, the modification incorrectly accounted for the number of nets (i.e. multiplied by 2 / N). Consequently, the swept area, and corresponding relative abundance and biomass values, were under-estimated when two nets were sampled (i.e. multiplied by 2 / 2 = 1) and over-estimated when one net was sampled (i.e. multiplied by 2 / 1 = 2).

The equation has been redefined as follows:

$$A = [(H * S * D) / 10{,}000] * N$$

Relative abundance and biomass per swept area were recalculated for each survey shot from 2019/20 to 2023/24 using the redefined equation. Additionally, in the process of validating analyses between excel and R, minor errors in the database were identified and corrected (e.g. shot type mislabelled, missing / duplicate data entry).

Table C.1. Sample sizes for bycatch monitoring in the SGPF during October/November and February/March surveys from October/November 2019 to February/March 2024, including the ratio of nets (i.e. number of shots that species were recorded for one and two nets) sampled at locations bycatch was encountered, is provided for each sampling period. *for some shots, the number of nets sampled varied among species (e.g. Southern Calamari and Eastern Balmain Bug = 2 nets and other spp. = 1 net), and these shots are included on both sides of the ratio.

Season	Survey	'Blue crab'	'Fish'	'By-product/ TEPs'	Ratio of nets (1:2) *
2019/20	Oct/Nov	14	14	0	**25**:3
2019/20	Feb/Mar	48	43	99	**108**:33
2020/21	Oct/Nov	58	57	58	59:**112**
2020/21	Feb/Mar	48	50	76	79:79
2021/22	Oct/Nov	58	57	57	64:**102**
2021/22	Feb/Mar	49	50	74	66:**77**
2022/23	Oct/Nov	57	56	56	**100**:59
2022/23	Feb/Mar	48	46	95	**107**:36
2023/24	Oct/Nov	58	57	52	**88**:62
2023/24	Feb/Mar	43	46	90	**90**:43

How did the error impact the results for bycatch monitoring?

The corrected biomass for each survey (Table C.2) resulted in a shift in the ranks of non-TEP bycatch species (Table C.3). Across both assessment periods, each species experienced at least two changes in rank, except for Blue Swimmer Crab (highest rank) and Southern Garfish (lowest rank). There were a total of 36 rank changes (30%).

Using the redefined equation for both assessment periods identified that bycatch biomass was previously under-estimated by an average of 120 g ha^{-1} (30%) across the twelve key species sampled (Table C.4), with the under-estimation primarily being driven by data analysed in the later assessment period (Oct/Nov 2022 to Feb/Mar 2024). The percent change for each species ranged between 0% (King George Whiting, Assessment period 1) to 251% (Bluespotted Goatfish, Assessment period 2). Historical spatial maps of biomass and abundance were also corrected for 2019/20, 2020/21 and 2021/22 financial years (Figure C.1 to Figure C.13).

Table C.2. Mean ± SE corrected biomass (g ha^{-1}) of non-TEPs bycatch species, by survey year and month. Sites were sampled by SGPF from October/November 2019 to February/March 2024. SE = standard error. Mean prawn catch (biomass, g ha^{-1}) is also provided

Year	2019	2020		2021		2022		2023		2024
Species	**Oct/Nov**	**Feb/Mar**	**Oct/Nov**	**Feb/Mar**	**Oct/Nov**	**Feb/Mar**	**Oct/Nov**	**Feb/Mar**	**Oct/Nov**	**Feb/Mar**
Blue Swimmer Crab	10268 ± 2718	5875 ± 1368	6029 ± 1681	7461 ± 1239	4233 ± 509	4395 ± 681	3544 ± 466	5160 ± 927	3962 ± 447	3547 ± 650
Skipjack Trevally	282 ± 82	1015 ± 551	928 ± 210	998 ± 417	1253 ± 318	1728 ± 639	911 ± 265	1451 ± 660	1431 ± 303	3023 ± 1060
Bluefin Leatherjacket	68 ± 26	2268 ± 529	984 ± 266	2359 ± 695	301 ± 69	796 ± 178	187 ± 41	327 ± 89	210 ± 39	680 ± 343
Port Jackson Shark	586 ± 208	358 ± 111	448 ± 93	418 ± 114	741 ± 128	572 ± 129	385 ± 90	622 ± 152	738 ± 168	532 ± 130
Rough Leatherjacket	380 ± 68	236 ± 63	273 ± 41	319 ± 70	373 ± 85	216 ± 57	196 ± 40	243 ± 46	1072 ± 483	1641 ± 559
Toothbrush Leatherjacket	38 ± 12	19 ± 10	552 ± 330	260 ± 173	573 ± 251	98 ± 39	123 ± 37	1153 ± 867	95 ± 46	307 ± 192
Southern Calamari	272 ± 45	394 ± 43	277 ± 23	303 ± 33	243 ± 19	332 ± 24	227 ± 16	441 ± 39	222 ± 21	288 ± 38
Bluespotted Goatfish	13 ± 13	151 ± 36	126 ± 33	215 ± 61	264 ± 39	473 ± 95	314 ± 45	374 ± 69	319 ± 55	239 ± 75
Eastern Balmain Bug	310 ± 70	26 ± 6	150 ± 20	27 ± 6	75 ± 11	23 ± 5	79 ± 9	16 ± 4	83 ± 13	20 ± 5
King George Whiting	79 ± 24	106 ± 41	48 ± 24	75 ± 24	43 ± 10	84 ± 28	26 ± 10	43 ± 16	43 ± 13	34 ± 14
Snapper	0	6 ± 6	1 ± 1	123 ± 94	1 ± 1	1 ± 1	9 ± 4	97 ± 71	10 ± 4	41 ± 22
Southern Garfish	0	1 ± 1	0.3 ± 0.3	1 ± 0	0	0	0.3 ± 0.2	0.3 ± 0.3	1 ± 1	0
Western King Prawn	12919	15716	9207	10562	5869	8932	6784	12664	5230	9537

Table C.3. The corrected rank of non-TEPs bycatch species sampled by the SGPF for surveys completed from October/November 2019 to February/March 2024. Ranks that have changed post – correction were highlighted by providing the previously reported (e.g. Heldt and Hooper 2023) rank in parentheses.

Year	**2019**	**2020**		**2021**		**2022**		**2023**		**2024**
Species	**Oct/Nov**	**Feb/Mar**	**Oct/Nov**	**Feb/Mar**	**Oct/Nov**	**Feb/Mar**	**Oct/Nov**	**Feb/Mar**	**Oct/Nov**	**Feb/Mar**
Blue Swimmer Crab	1	1	1	1	1	1	1	1	1	1
Skipjack Trevally	5 (6)	3 (2)	3	3	2	2	2	2 (6)	2 (3)	2
Bluefin Leatherjacket	8	2 (3)	2	2	6	3	7	7 (4)	7	4
Port Jackson Shark	2	5	5	4 (5)	3	4	3 (4)	4 (3)	4	5
Rough Leatherjacket	3	6	7	5 (8)	5	7	6 (5)	8 (7)	3 (2)	3
Toothbrush Leatherjacket	9	10	4	7 (6)	4	8	8	3 (10)	8 (9)	6 (7)
Southern Calamari	6 (5)	4	6	6 (4)	8	6	5 (6)	5 (2)	6	7 (6)
Bluespotted Goatfish	10	7	9 (8)	8 (9)	7	5	4 (3)	6 (5)	5	8
Eastern Balmain Bug	4	9	8 (9)	11	9	10	9 (10)	11	9 (8)	11 (10)
King George Whiting	7	8	10	10	10	9	10 (9)	10 (9)	10	10 (9)
Snapper	11.5	11	11	9 (7)	11	11	11	9 (8)	11	9 (11)
Southern Garfish	11.5	12	12	12	12	12	12	12	12	12

Table C.4. Overall mean biomass (g ha^{-1}) of non-TEPs bycatch species for previously reported (e.g. Heldt and Hooper 2023) and corrected mean biomass, for each assessment period sampled by SGPF from October/November 2019 to February/March 2024. The difference between the mean biomass for reported and corrected values is provided, with a positive value indicating the error resulted in under-estimation and a negative value over-estimation. The percent change between reported and corrected values is also provided in parentheses. SE = standard error.

	Assessment Period 1 Oct/Nov 2019 to Feb/Mar 2022					**Assessment Period 2 Oct/Nov 2022 to Feb/Mar 2024**				
	Reported		**Corrected**		**Difference**	**Reported**		**Corrected**		**Difference**
Species	Mean biomass	SE	Mean biomass	SE	Mean biomass	Mean biomass	SE	Mean biomass	SE	Mean biomass
Blue Swimmer Crab	5215	505	5798	528	583 (11%)	2771	322	4039	313	1268 (45%)
Skipjack Trevally	1490	308	1137	184	-353 (24%)	718	120	1651	304	933 (130%)
Bluefin Leatherjacket	1136	179	1216	173	80 (7%)	593	163	335	82	-258 (44%)
Port Jackson Shark	645	76	520	51	-125 (19%)	370	78	570	69	200 (54%)
Southern Calamari	354	18	310	13	-44 (12%)	273	74	299	16	26 (10%)
Toothbrush Leatherjacket	514	174	308	94	-206 (40%)	272	37	388	200	116 (43%)
Rough Leatherjacket	337	45	292	28	-45 (13%)	233	35	774	188	541 (232%)
Bluespotted Goatfish	284	42	234	25	-50 (18%)	89	40	312	30	223 (251%)
King George Whiting	69	11	69	11	0 (0%)	47	7	37	7	-10 (21%)
Snapper	40	34	24	18	-16 (40%)	41	11	36	17	-5 (12%)
Eastern Balmain Bug	70	6	67	6	-3 (4%)	27	16	48	4	21 (78%)
Southern Garfish	0.2	0.1	0.3	0.2	0.1 (50%)	0.3	0.2	0.5	0.2	0.2 (67%)

a)

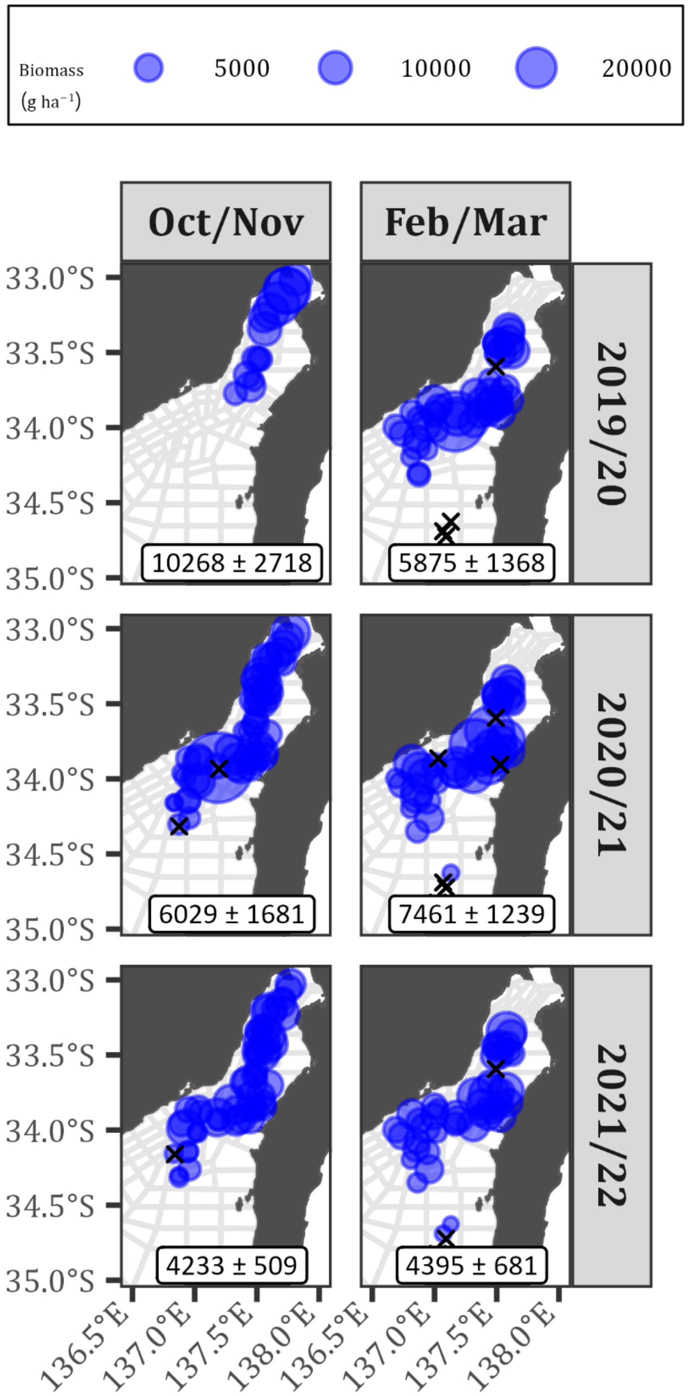


Figure C.1. Corrected biomass (a) and abundance (b) of Blue Swimmer Crab sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

b)

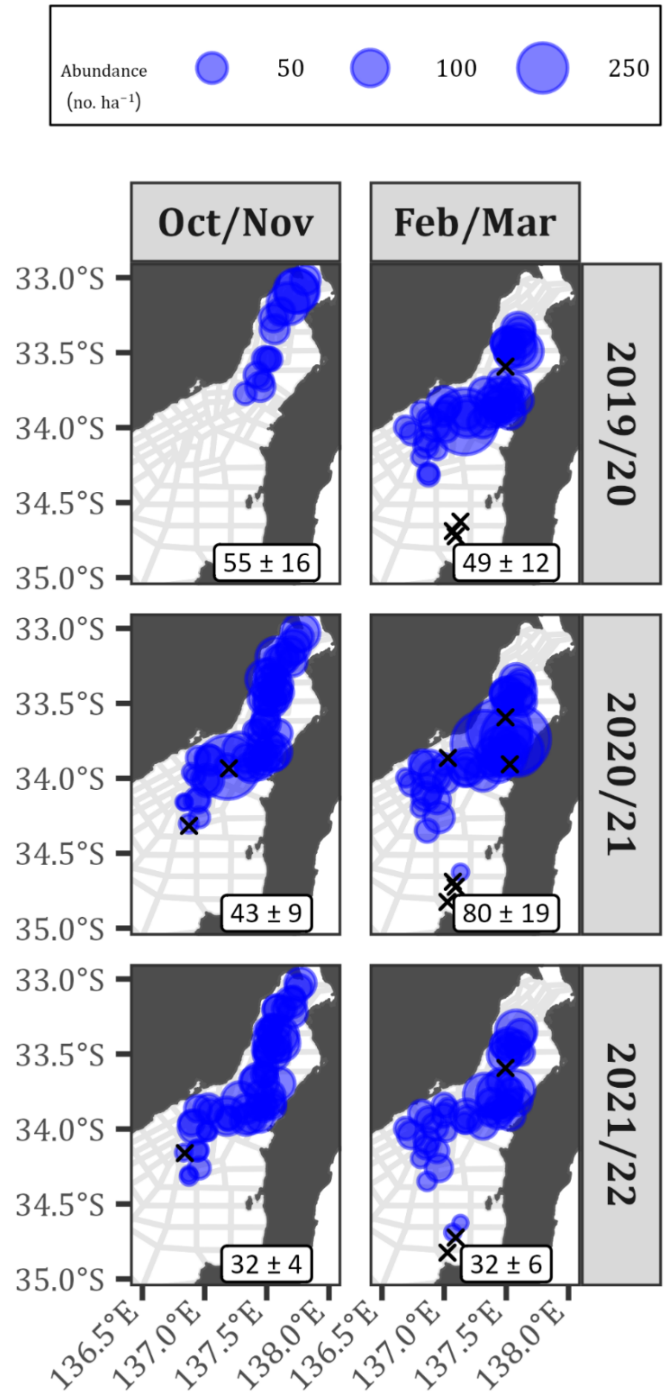


Figure C.1. cont. Corrected biomass (a) and abundance (b) of Blue Swimmer Crab sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

a)

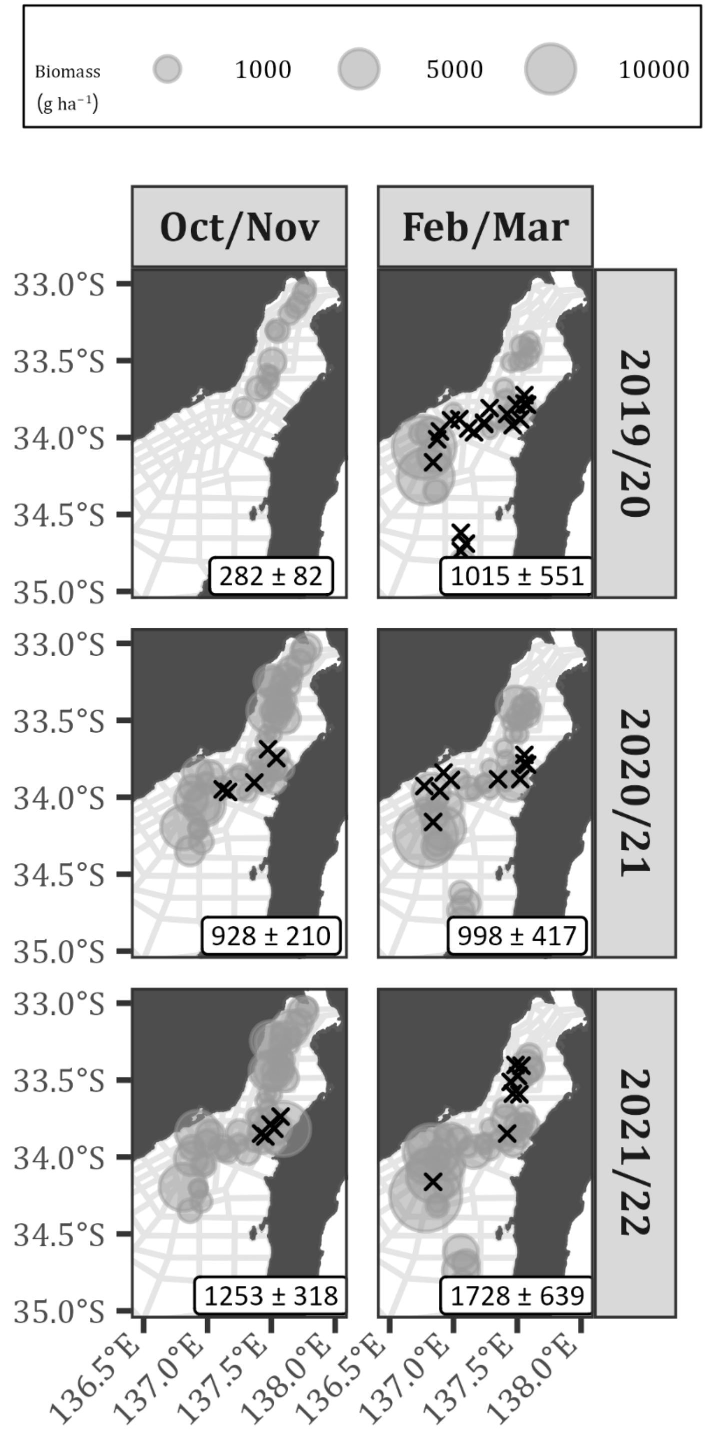


Figure C.2. Corrected biomass (a) and abundance (b) of Skipjack Trevally sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

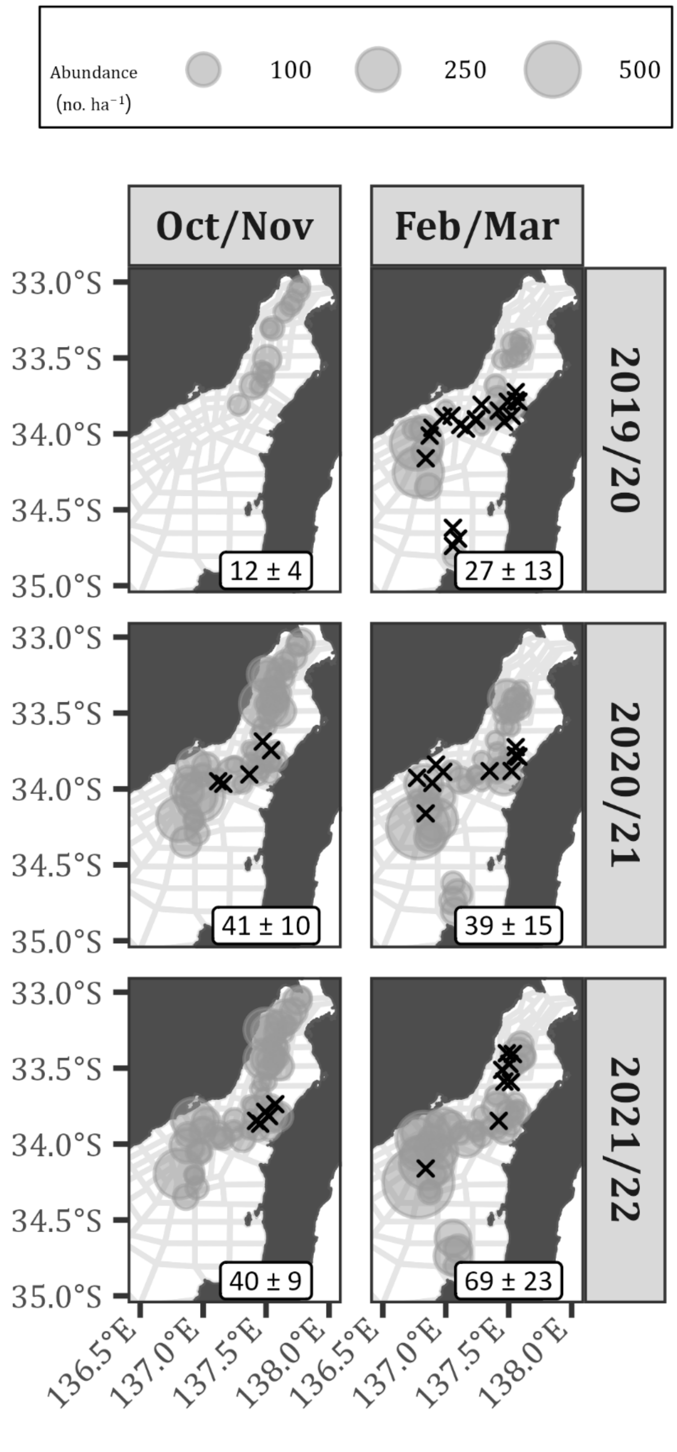


Figure C.2. cont. Corrected biomass (a) and abundance (b) of Skipjack Trevally sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

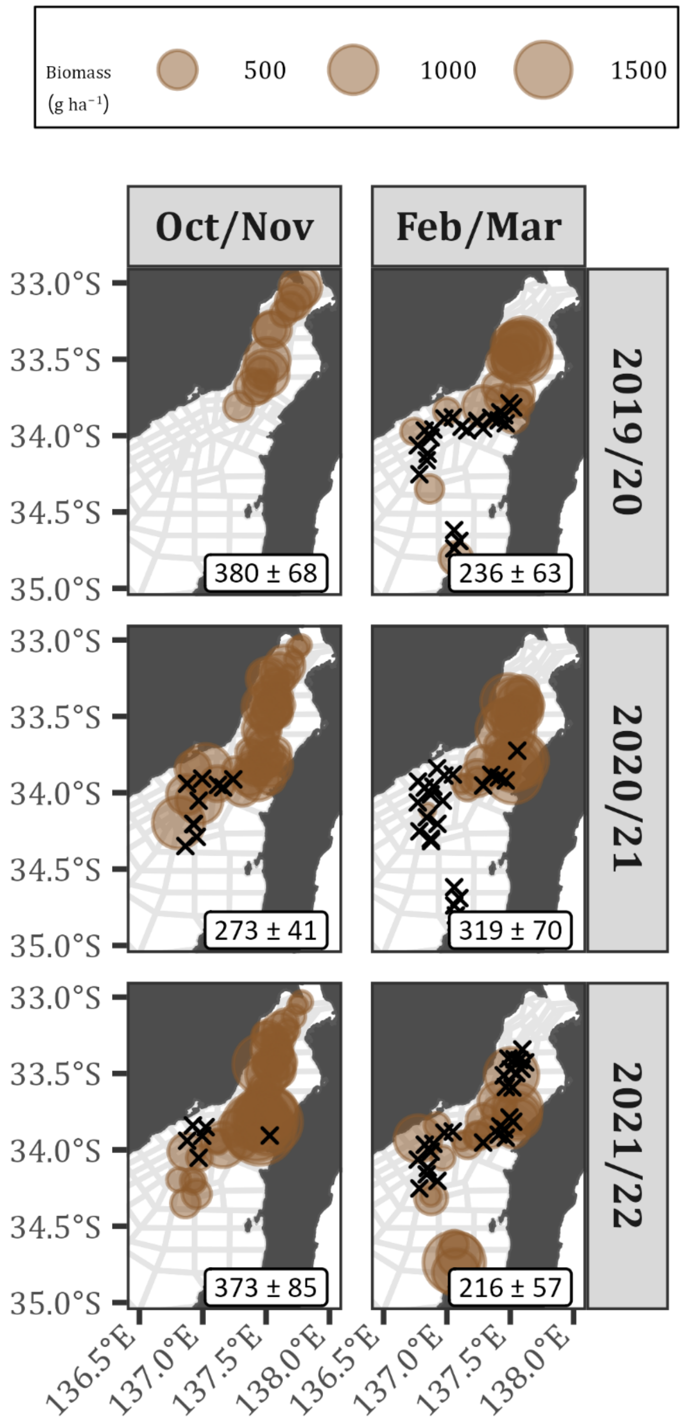


Figure C.3. Corrected biomass (a) and abundance (b) of Rough Leatherjacket sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

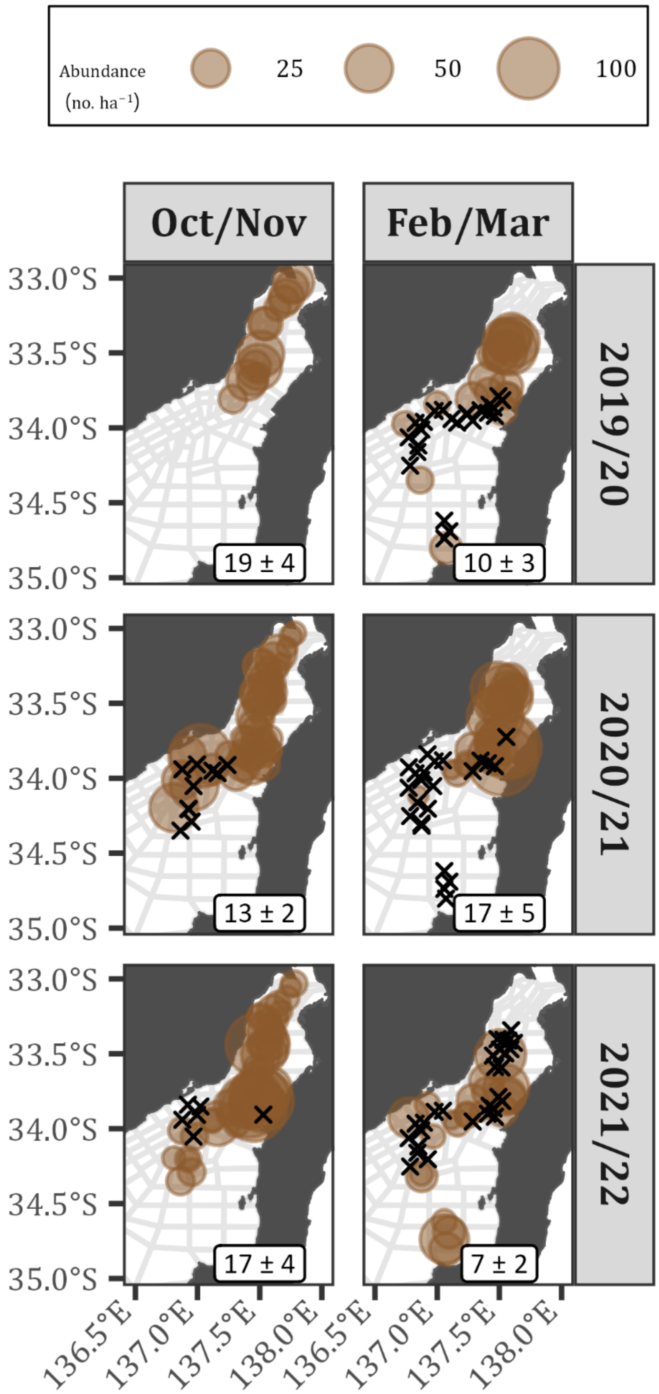


Figure C.3. cont. Corrected biomass (a) and abundance (b) of Rough Leatherjacket sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

a)

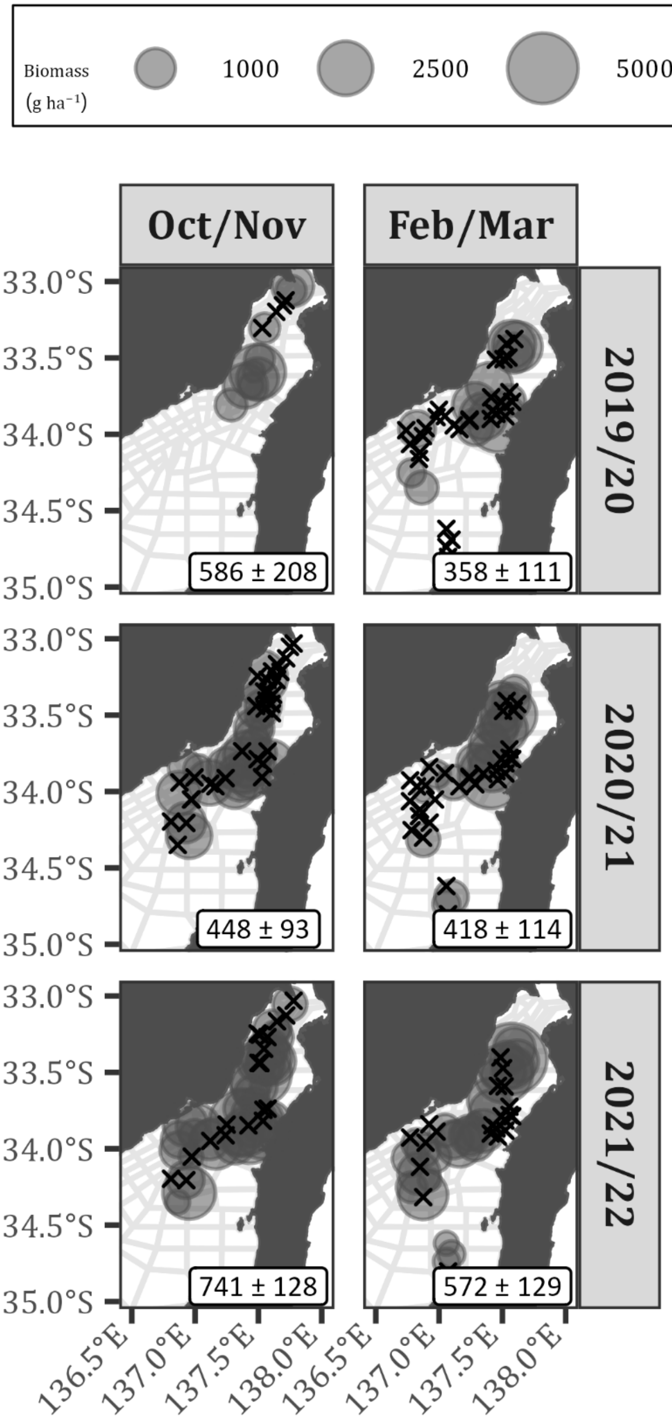


Figure C.4. Corrected biomass (a) and abundance (b) of Port Jackson Shark sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

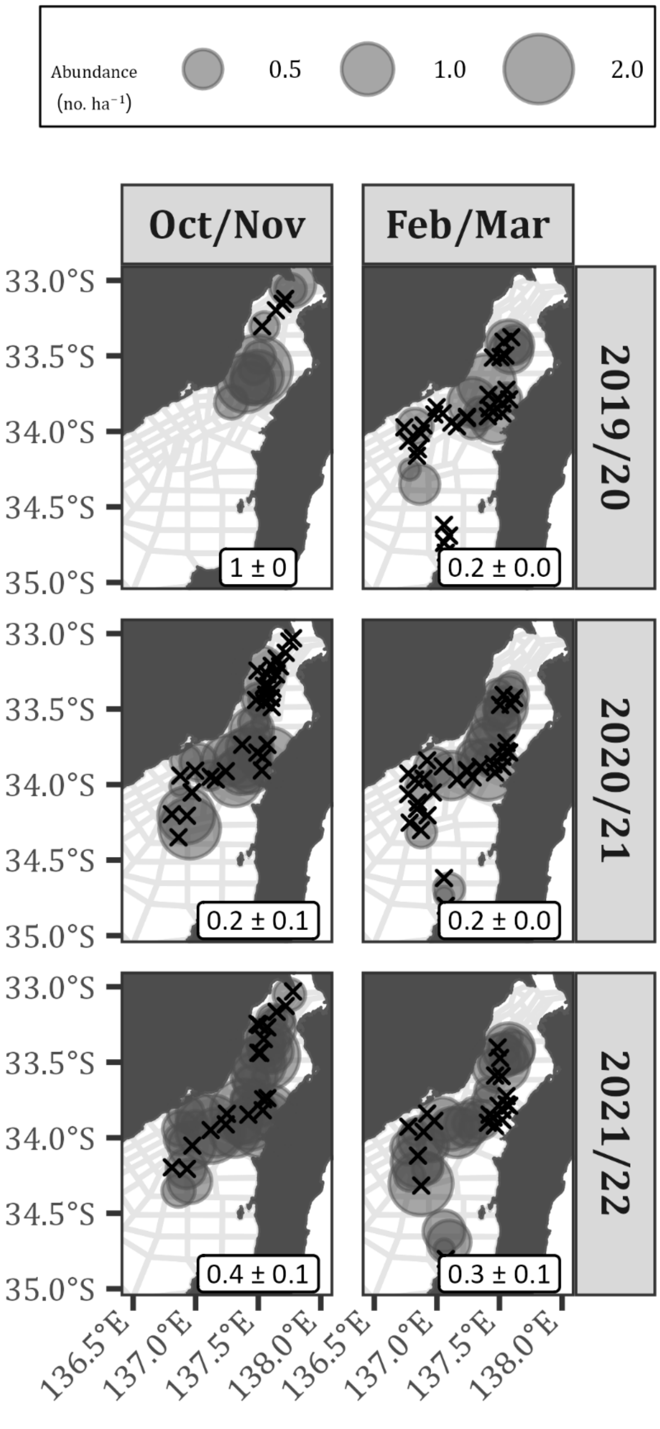


Figure C.4. cont. Corrected biomass (a) and abundance (b) of Port Jackson Shark sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

a)

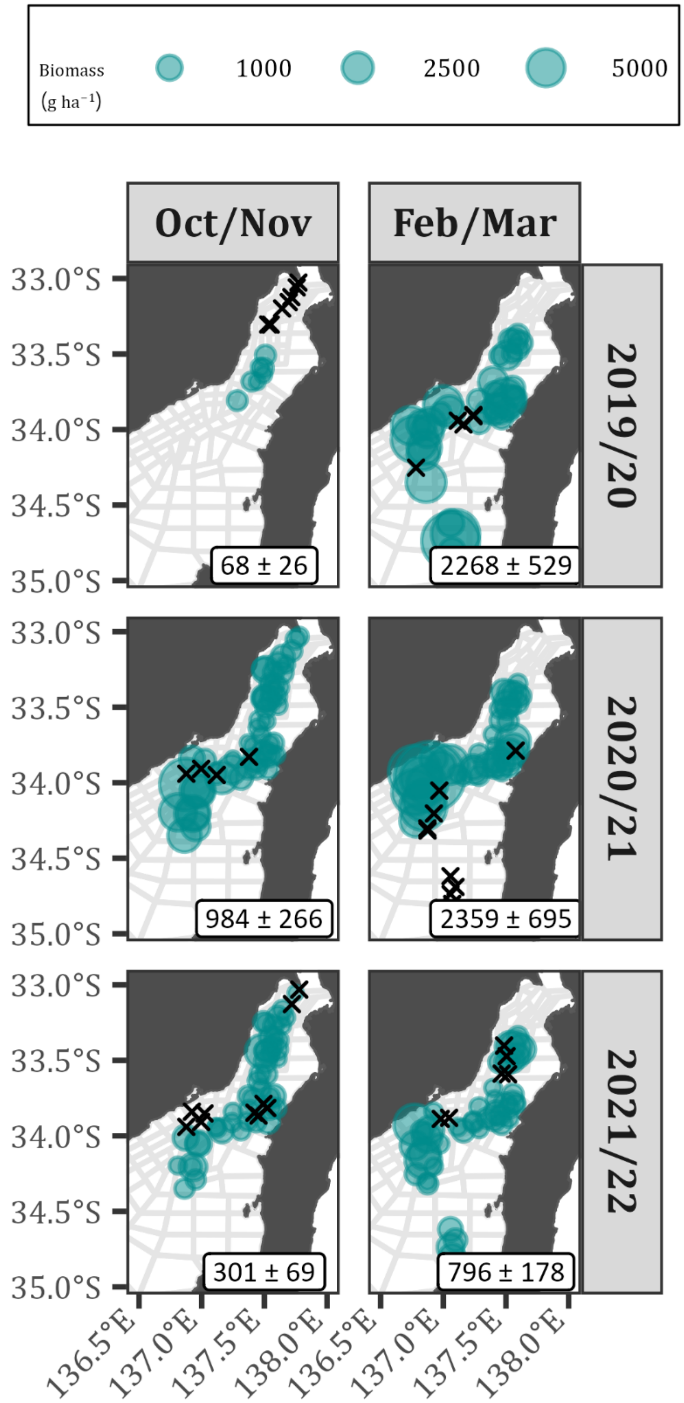


Figure C.5. Corrected biomass (a) and abundance (b) of Bluefin Leatherjacket sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

b)

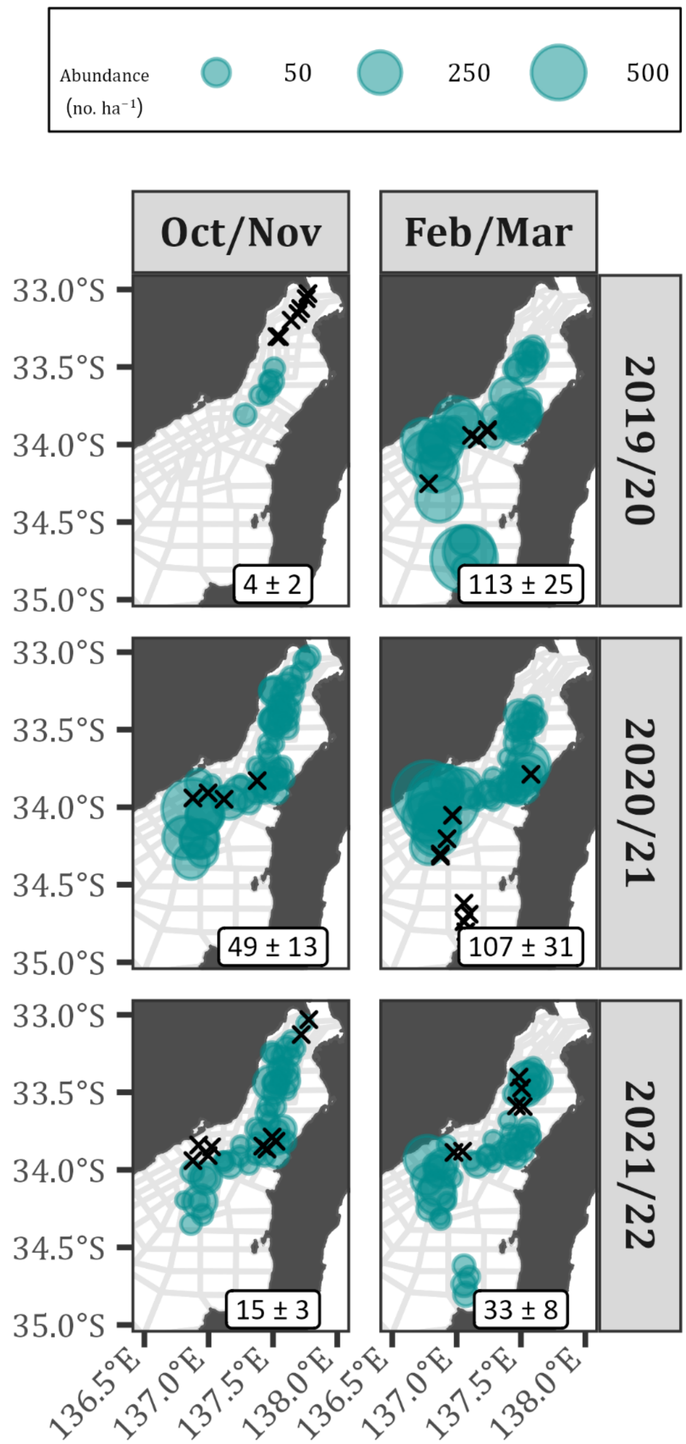


Figure C.5. cont. Corrected biomass (a) and abundance (b) of Bluefin Leatherjacket sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

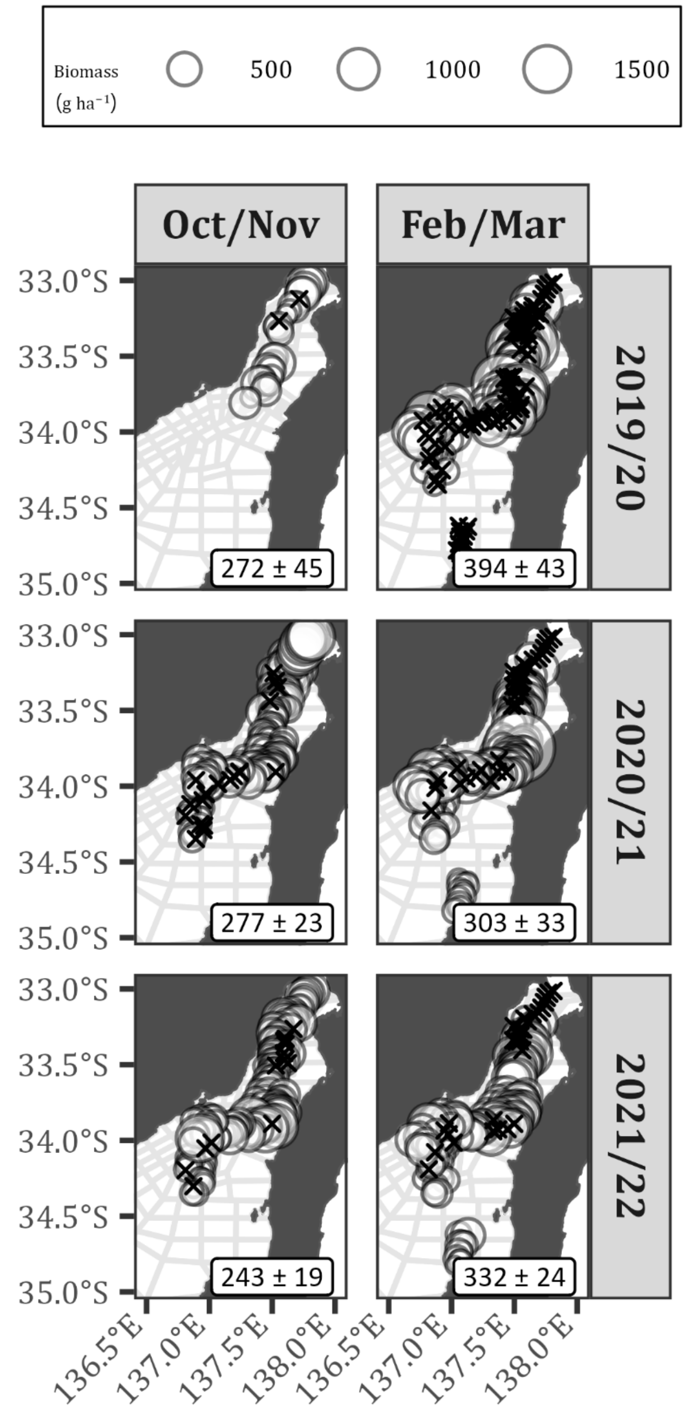


Figure C.6. Corrected biomass (a) and abundance (b) of Southern Calamari sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

b)

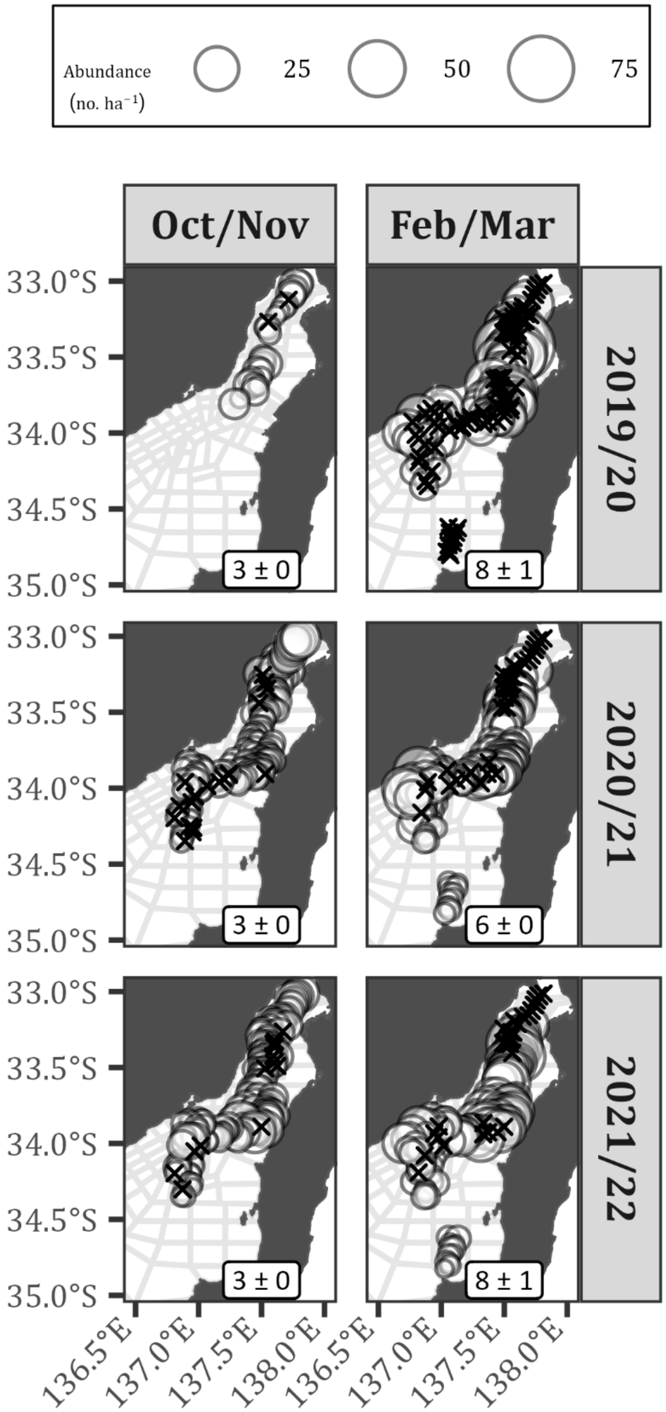


Figure C.6. cont. Corrected biomass (a) and abundance (b) of Southern Calamari sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

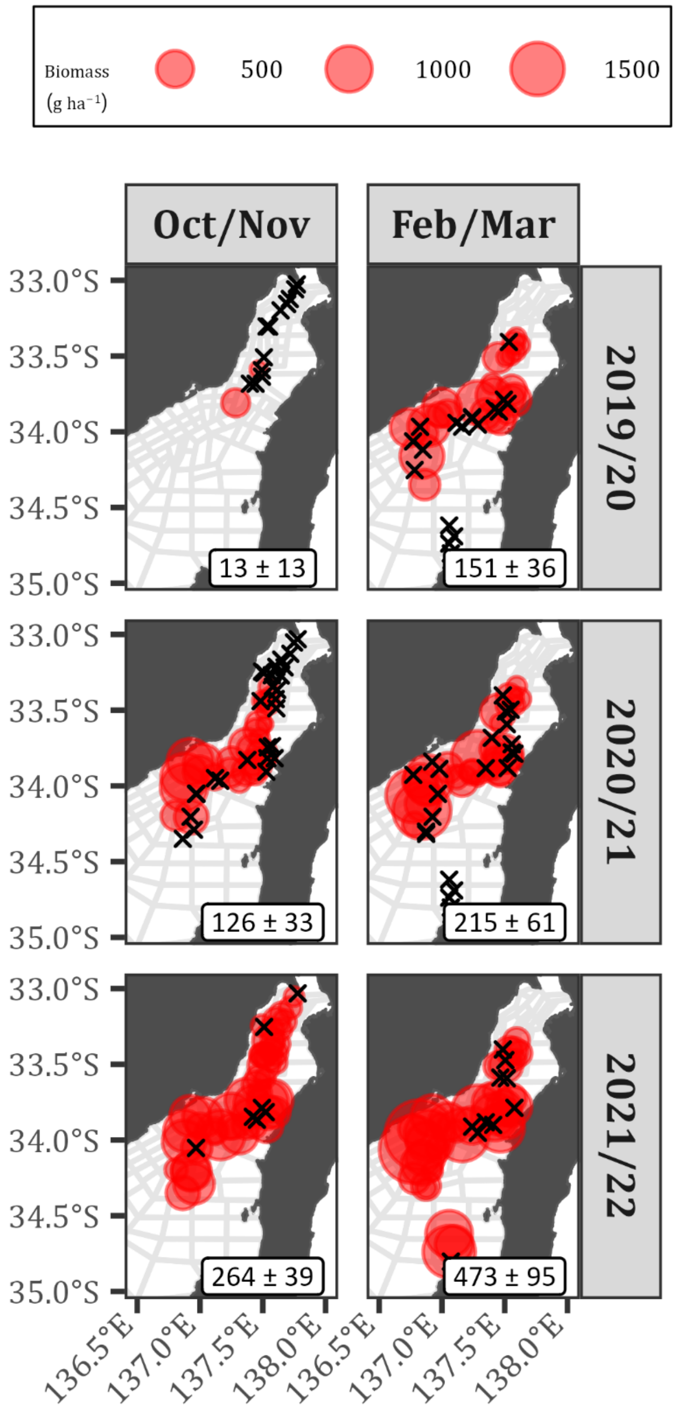


Figure C.7. Corrected biomass (a) and abundance (b) of Bluespotted Goatfish sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

b)

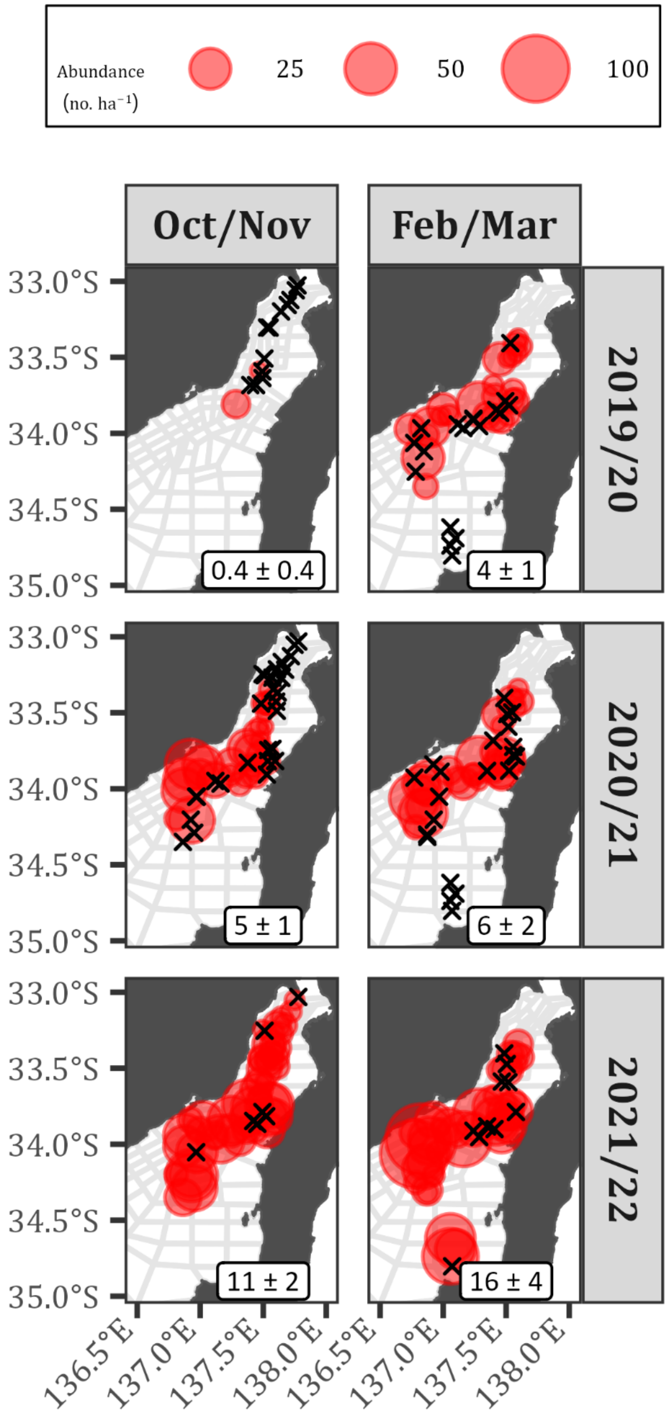


Figure C.7. cont. Corrected biomass (a) and abundance (b) of Bluespotted Goatfish sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

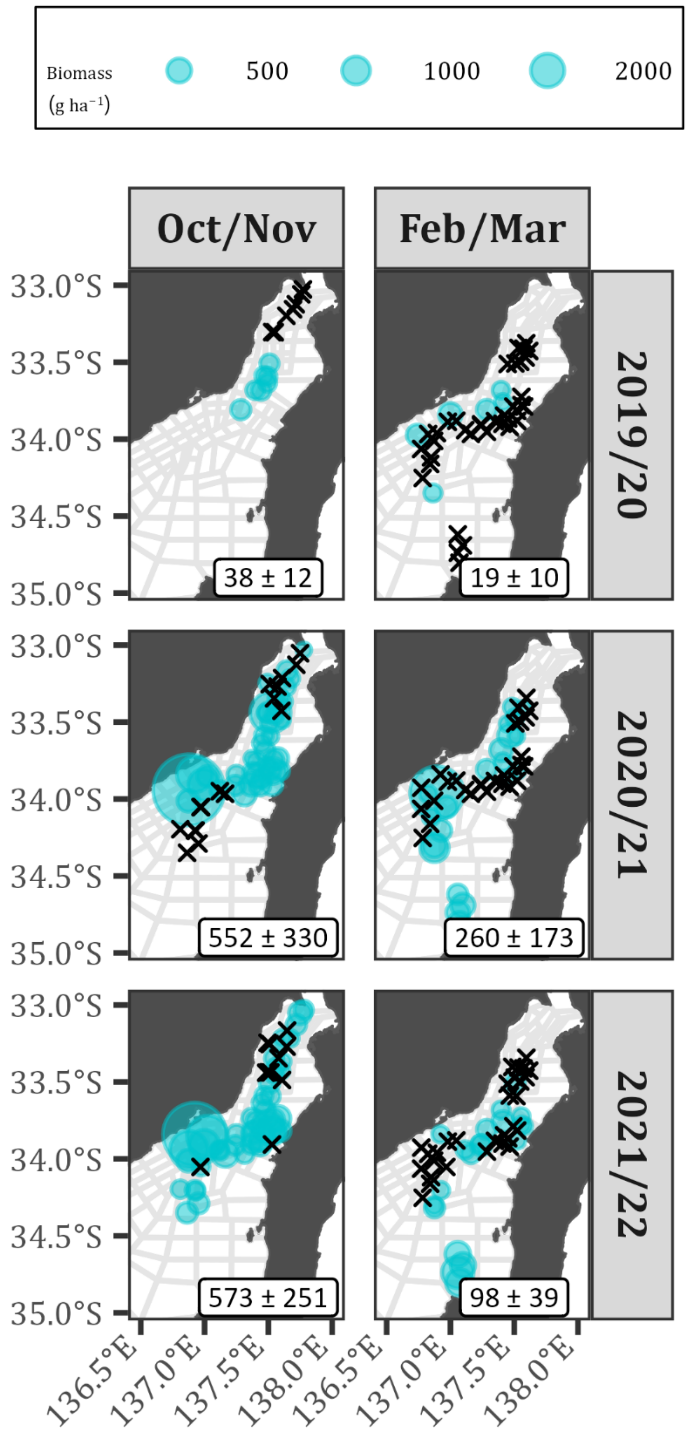


Figure C.8. Corrected biomass (a) and abundance (b) of Toothbrush Leatherjacket sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

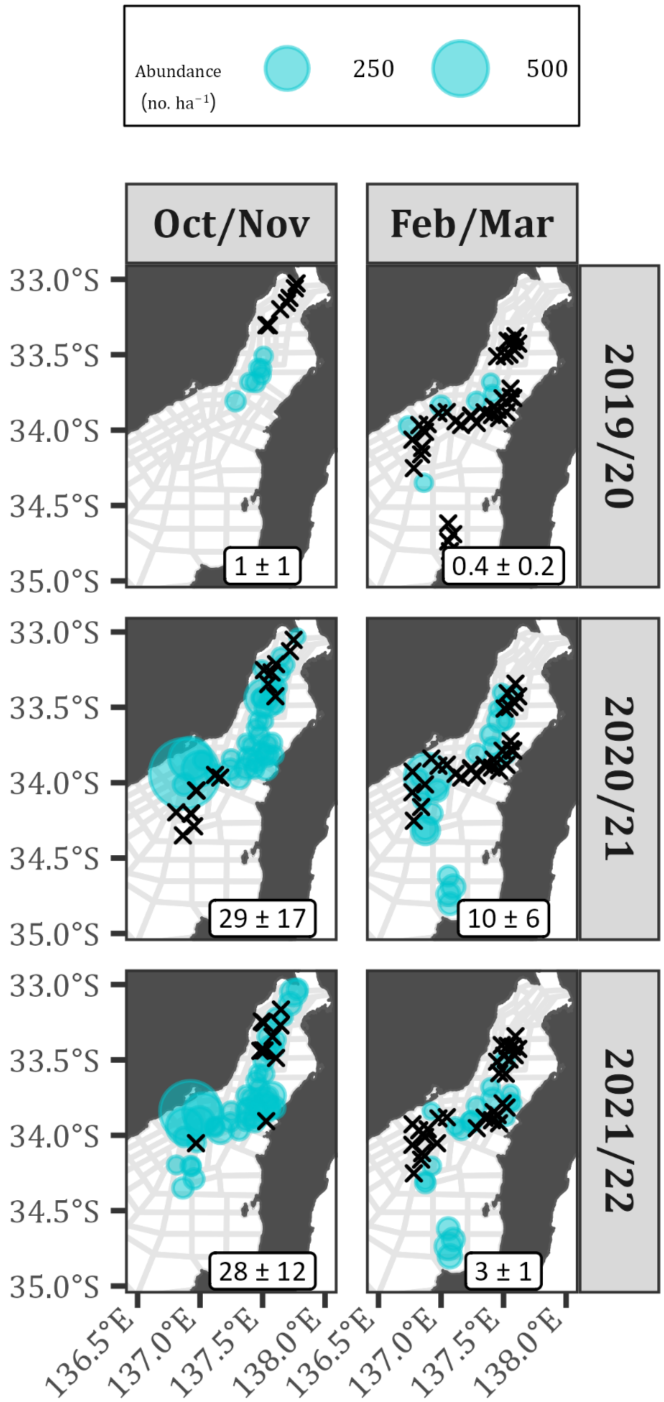


Figure C.8. cont. Corrected biomass (a) and abundance (b) of Toothbrush Leatherjacket sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

a)

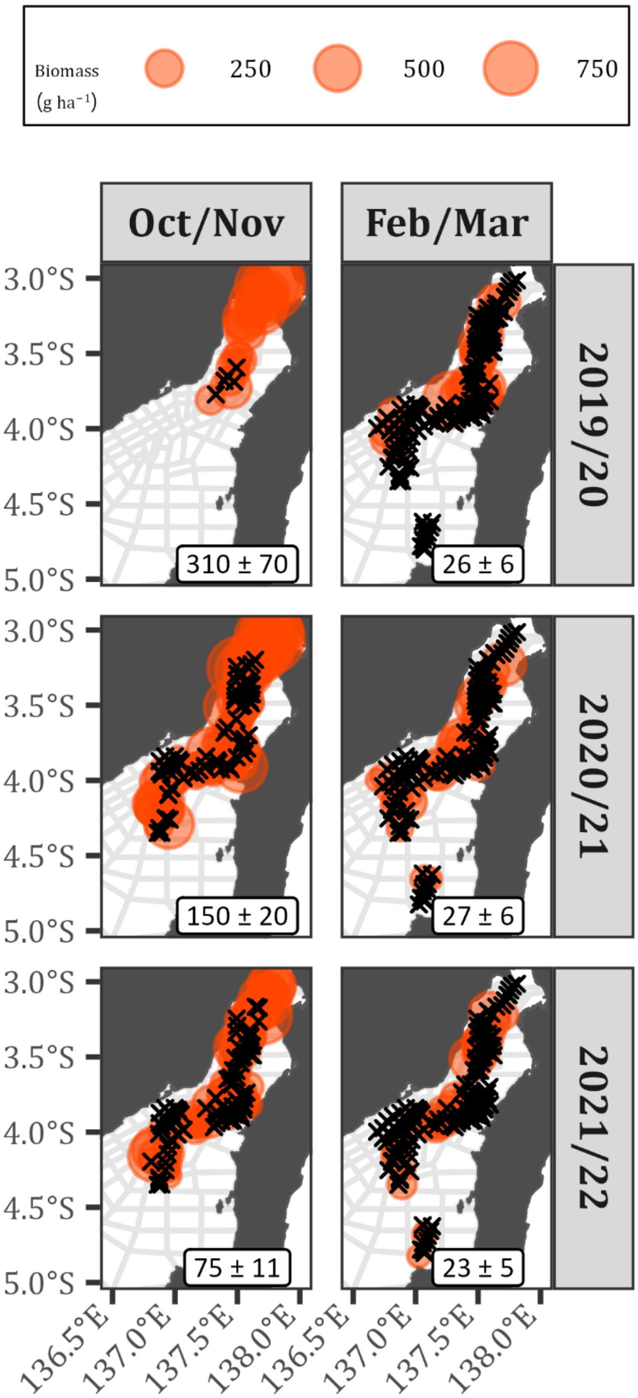


Figure C.9. Corrected biomass (a) and abundance (b) of Eastern Balmain Bug sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

b)

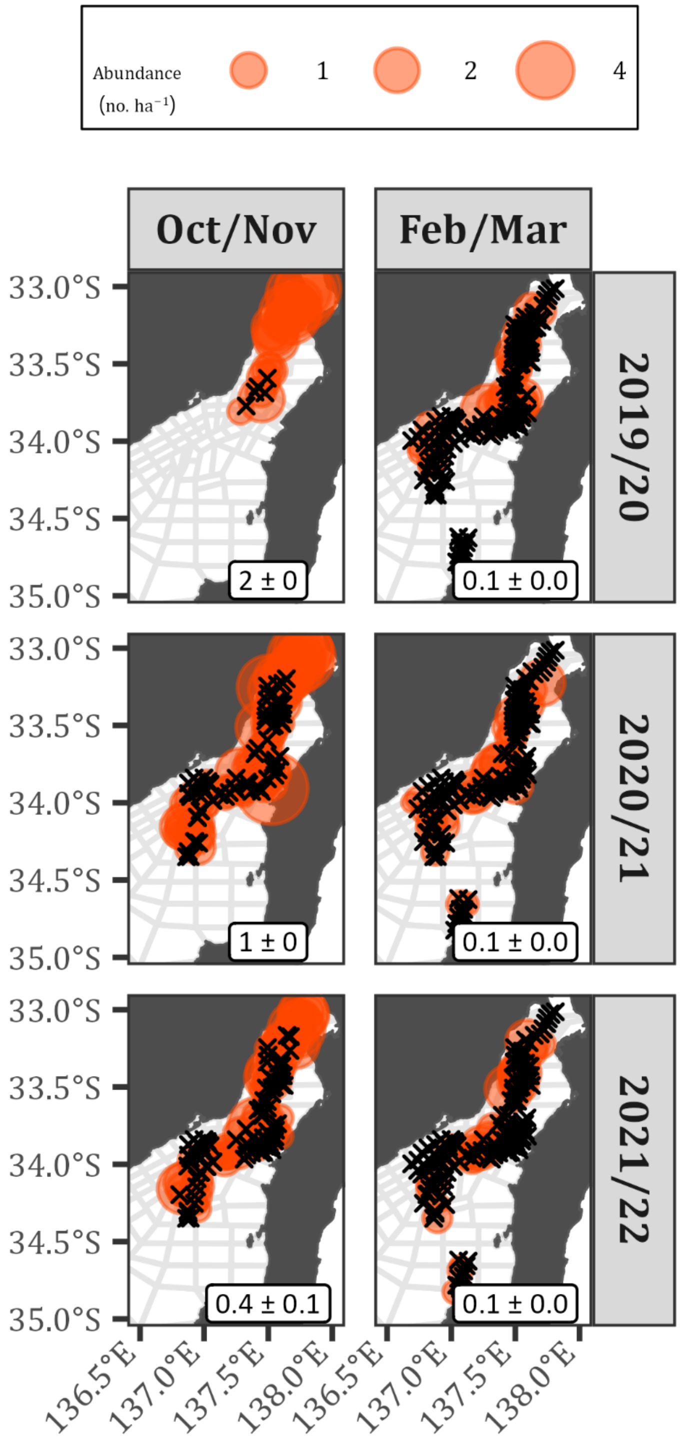


Figure C.9. cont. Corrected biomass (a) and abundance (b) of Eastern Balmain Bug sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

a)

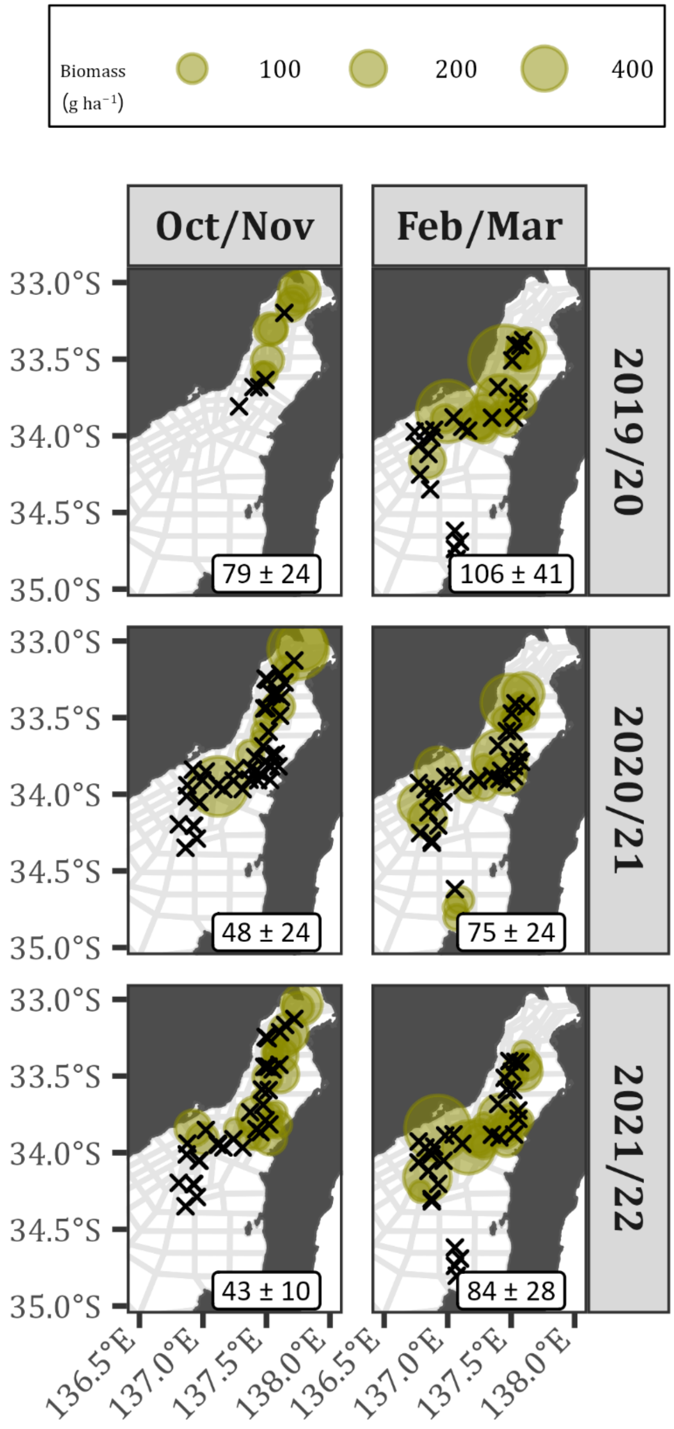


Figure C.10. Corrected biomass (a) and abundance (b) of King George Whiting sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

b)

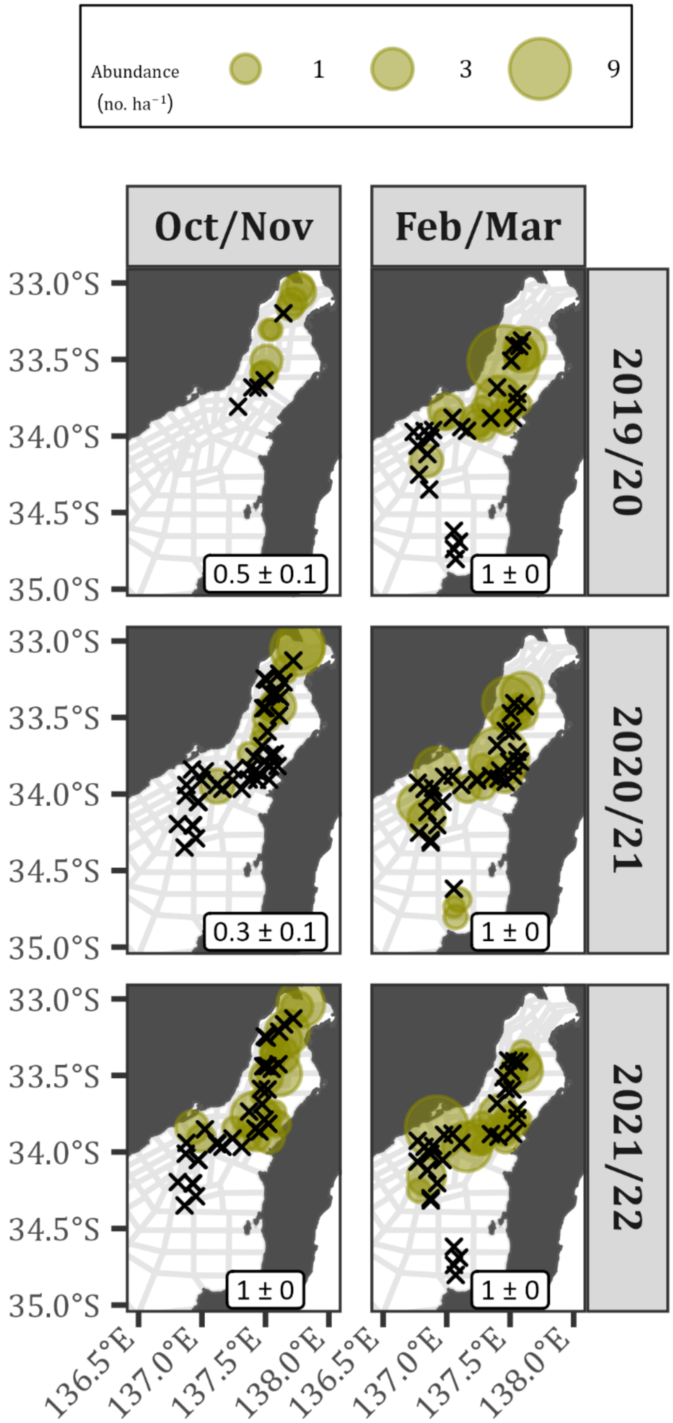


Figure C.10. cont. Corrected biomass (a) and abundance (b) of King George Whiting sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

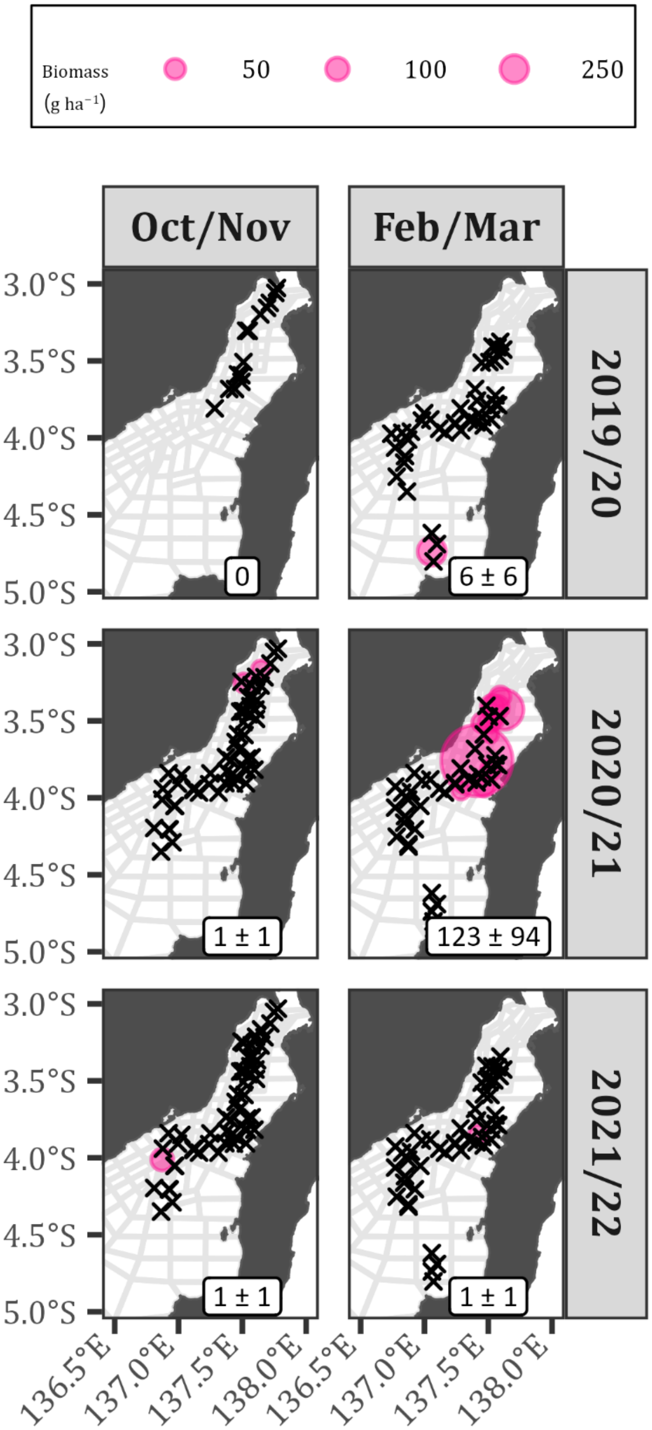


Figure C.11. Corrected biomass (a) and abundance (b) of Snapper sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

b)

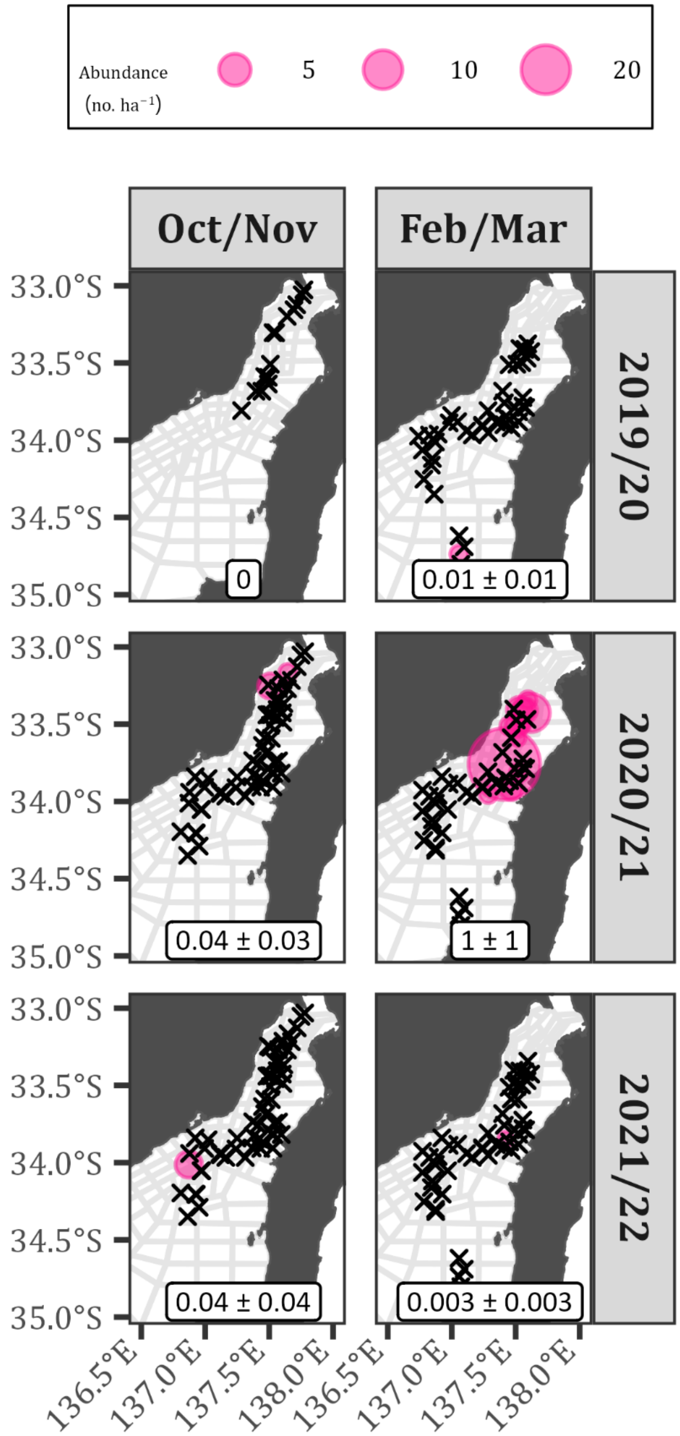


Figure C.11. cont. Corrected biomass (a) and abundance (b) of Snapper sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

a)

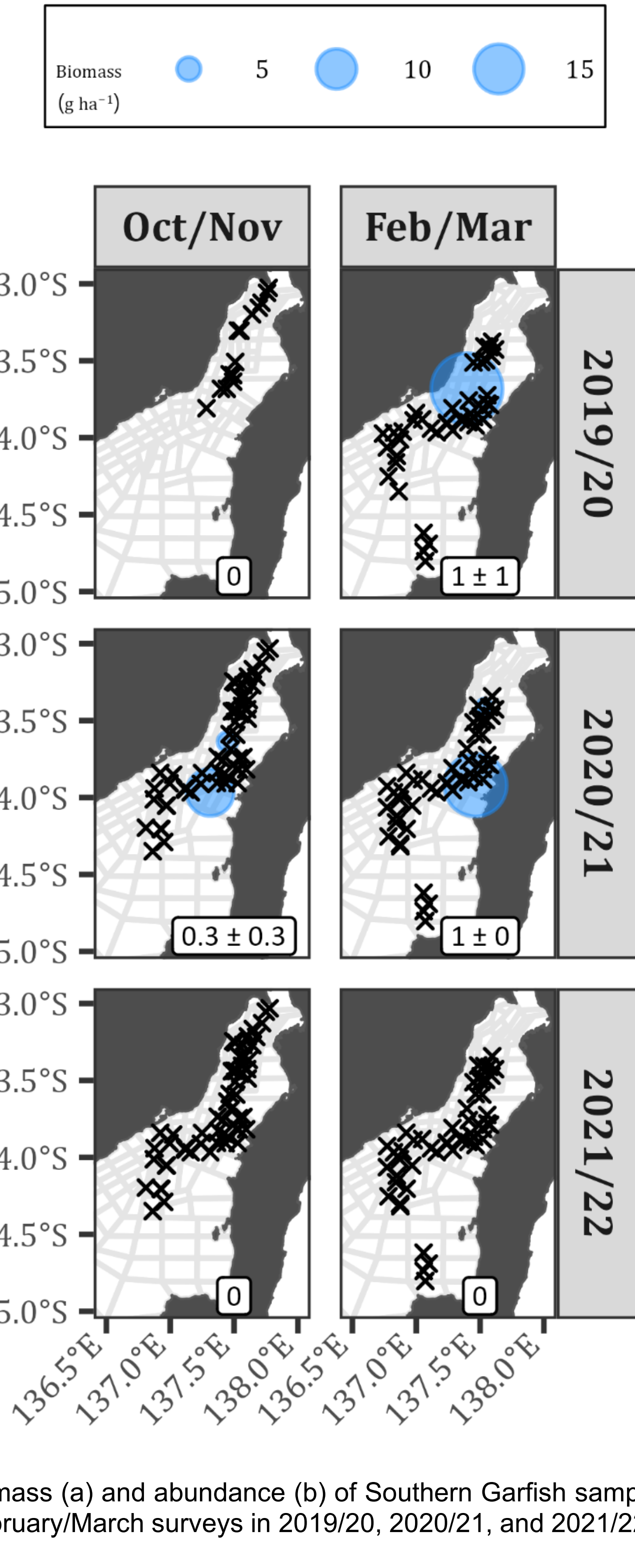


Figure C.12. Corrected biomass (a) and abundance (b) of Southern Garfish sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an ‘x’ indicates abundance/biomass is zero.

b)

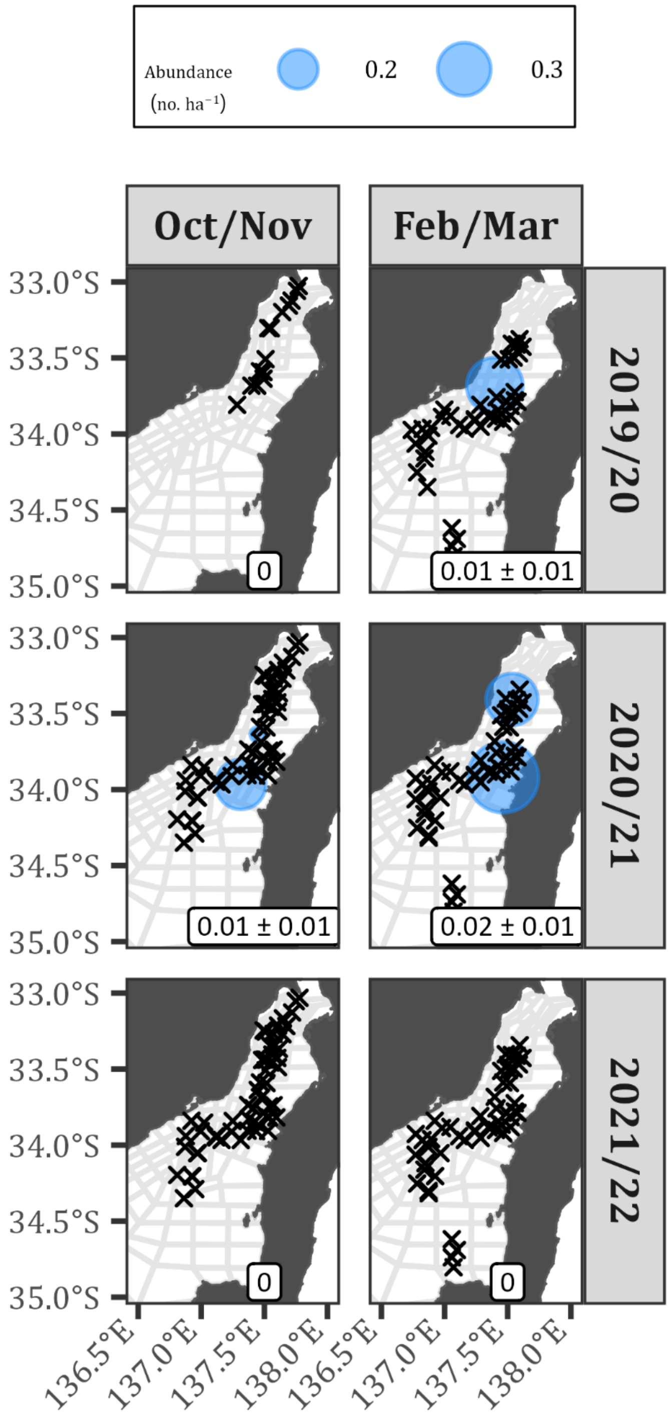


Figure C.12. cont. Corrected biomass (a) and abundance (b) of Southern Garfish sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

a)

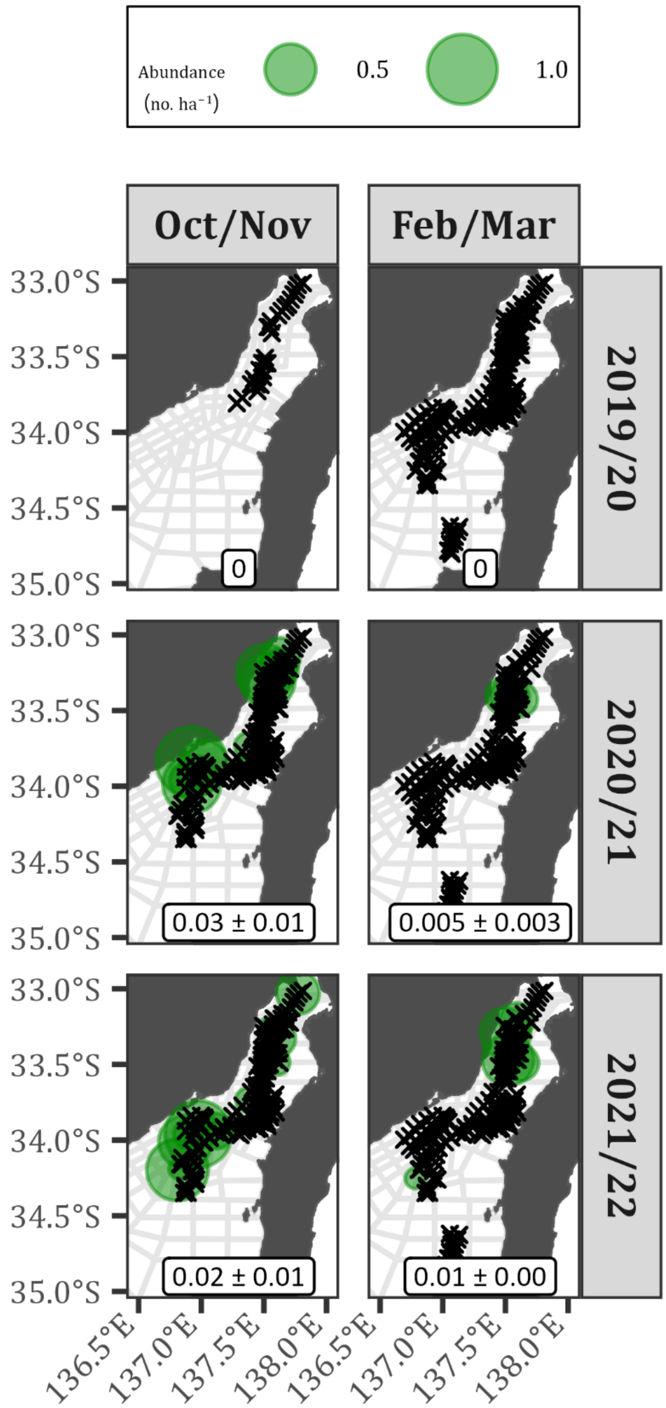


Figure C.13. Corrected abundance of Syngnathids sampled by the SGPF during October/November and February/March surveys in 2019/20, 2020/21, and 2021/22. Mean (± SE) is shown for each survey, and an 'x' indicates abundance/biomass is zero.

APPENDIX D. RECRUITMENT INDEX AND EGG PRODUCTION

Like many fisheries, the stock-recruitment relationship for the SGPF is not well understood, and there is some uncertainty regarding the effect of egg production on eventual recruitment to the fishable stock. Because recruitment is a direct measure of newly recruited prawns (i.e. '20+' grade prawns), it provides a more immediate indicator of fishery health than egg production.

Recruitment index

The recruitment index was calculated as the survey $CPUE_{recruits}$ ('20+' grade prawns) from 34 locations in the upper gulf during March surveys. This replaced the length-based measure of recruitment of Carrick (2003) as it is considered more representative of the sampled population and therefore more accurate (Advice Note to PIRSA Fisheries and Aquaculture, July 2018).

The mean survey $CPUE_{recruits}$ from 34 locations during February/March surveys (the recruitment index) has remained above its historical RP (2.38 lb min^{-1}; PIRSA 2014) since the current survey design began in 2004/05 (Figure D.1). The recruitment index decreased from 2021/22 (6.20 ± 0.68 lb min^{-1}) to 2022/23 and 2023/24 (5.07 ± 0.50 lb $min^{-1}$and 3.89 ± 0.45, respectively), and the index in 2023/24 was the fifth lowest on record (Figure D.1). Whilst this RP and indicator is considered the most reliable index of recruitment, it has no formal role in the current harvest strategy (PIRSA 2020).

Egg production

Annual egg production of Western King Prawns in Spencer Gulf was estimated using an egg production model, which has been used since 2004/05. The model calculations are based on biological data collected from the October/November survey, and rely on several parameters and assumptions: (i) catchability of prawns is constant; (ii) females spawn a determinate number of times (three) in a spawning period; (iii) spawning frequency does not vary with size; (iv) natural mortality is zero; (v) the proportion of females within each industry size grade category does not vary during the spawning period; and (vi) sex-specific length-frequency data are representative of the population (Noell and Hooper 2021). Mean egg production (M eggs trawl-h^{-1}) is interpreted as the potential number of fertilised eggs per trawl hour that females could have contributed throughout the spawning period. Further details are provided in Noell and Hooper 2021. This indicator is no longer used in the current harvest strategy (PIRSA 2020).

The estimated mean egg production was below the historical reference point (500 M eggs trawl-h^{-1}; PIRSA 2014) in 2022/23 (441 ± 26 M eggs trawl-h^{-1}) and increased to 583 ± 29 M eggs trawl-h^{-1} in 2023/24 (Figure D.2).

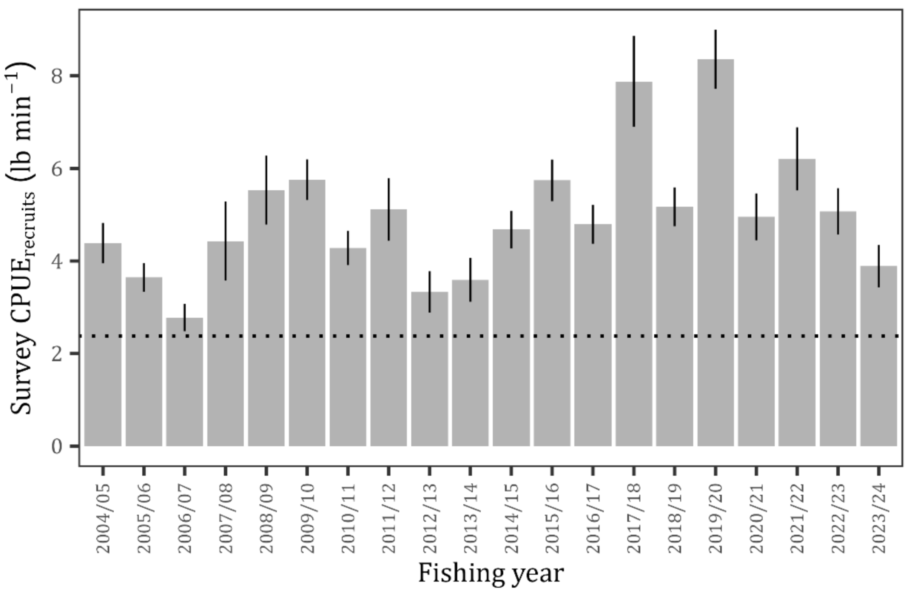


Figure D.1. Recruitment index (± 1 SE) from approximately 34 shot locations in upper Spencer Gulf during February/March surveys, 2004/05–2023/24. The dotted line represents the historical reference point (2.38 lb min^{-1}).

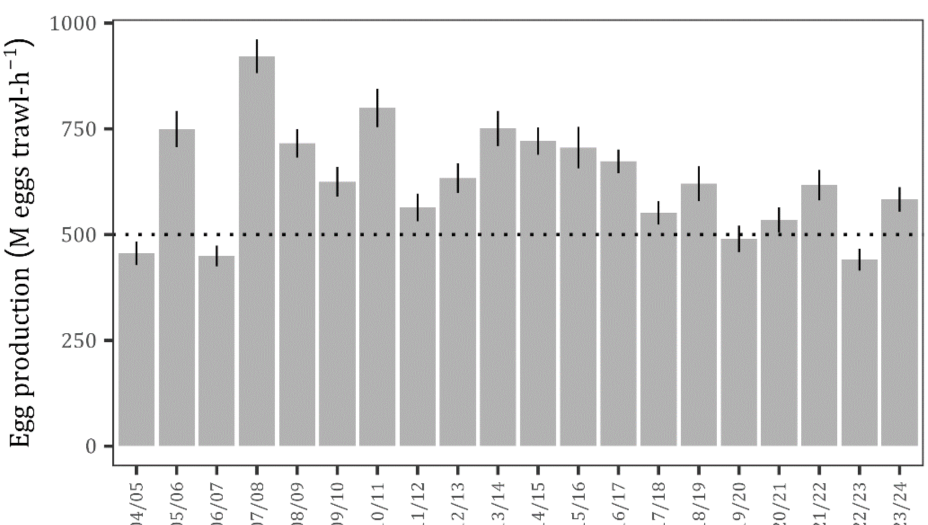


Figure D.2. Mean egg production (± 1 SE) during October/November surveys, 2004/05–2023/24. The dotted line indicates the historical reference point (500 M eggs trawl-h^{-1}).